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ABSTRACT

Project data is organized to provide a valid, simplified description of American adolescents which should be of use to guidance personnel. A chapter on educational achievement traits presents an overview of the factor solution for the abilities domain, and describes the compositions of the three factors that represent core achievement traits: verbal knowledges, English language, and mathematics. Following chapters discuss the compositions of three differential aptitude factors and five specialized knowledge factors, as well as the control factors of sex and grade. Several unsupported hypotheses are set forth including the assertion that abilities are more closely linked to gentics than are motives, and thus have a primacy over motives. Questions are suggested regarding the predictive validities for life adjustment criteria of the abilities and motives factors. It is anticipated that a sequel to this report, in preparation, will document the relevance of the factor rubrics and measures to major issues in educational psychology and educational and vocational guidance. (Author/CJ)

Project TALENT

MEASURING ADOLESCENT PERSONALITY

Paul R. Lohnes

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University of Pittsburgh

1966

PROJECT TALENT

Major Project TALENT Publications

Flanagan, J. C., Dailey, J. T., Shaycoft, Marion F., Orr, D. B., & Goldberg, I. Designing the study. (Final report to the U. S. Office of Education, Cooperative Research Project No. 635), University of Pittsburgh, Project TALENT Office, 1960.

Flanagan, J. C., Dailey, J. T., Shaycoft, Marion F., Orr, D. B., & Goldberg, I. Studies of the American high school. (Final report to the U. S. Office of Education, Cooperative Research Project No. 226), University of Pittsburgh, Project TALENT Office, 1962.

Shaycoft, Marion F., Dailey, J. T., Orr, D. B., Neyman, C. A., Jr., & Sherman, S. E. Studies of a complete age group - age 15. (Final report to the U. S. Office of Education, Cooperative Research Project No. 566), University of Pittsburgh, Project TALENT Office, 1963.

Flanagan, J. C., Davis, F. B., Dailey, J. T., Shaycoft, Marion F., Orr, D. B., Goldberg, I., & Neyman, C. A., Jr. The American high-school student. (Final report to the U. S. Office of Education, Cooperative Research Project No. 635), University of Pittsburgh, Project TALENT Office, 1964.

Flanagan, J. C., Cooley, W. W., Lohnes, P. R., Schoenfeldt, L. F., Holdeman,R.W.,Combs, Janet, and Becker,Susan J. Project TALENT: one-year follow-up studies. (Final report to the U. S. Office of Education, Cooperative Research Project No. 2333), University of Pittsburgh, Project TALENT Office, 1966.

MEASURING ADOLESCENT PERSONALITY

Project TALENT Five-Year Follow-up Studies

Interim Report I

Project No. 3051

Contract No. OE-6-10-065

Paul R. Lohnes
Professor of Education

The research reported herein was performed pursuant to a contract with the Office of Education, U. S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

University of Pittsburgh
Pittsburgh, Pennsylvania
1966

FOREWORD

Project TALENT, begun in the late 1950's under the leadership of Dr. John C. Flanagan, is a longitudinal study of a national random sample of over 400,000 high school students tested in 1960. Previous major reports of this project are listed on the inside front cover. Those reports represent final reports for specific contracts between the University of Pittsburgh and the United States Office of Education.

The Project TALENT follow-up studies are currently supported by a five-year contract. This present report is the first of a series of Interim Reports to be published under that contract.

The greatest potential contribution of Project TALENT is to high school guidance. In this report Dr. Paul R. Lohnes, our Director of Guidance Studies, moves us a very significant step closer toward realizing that potential. Here he has organized the Project TALENT data in a manner which provides a valid, yet simplified description of American adolescents. One thing which distinguishes this major research effort from "just another factor analysis" is the possibility of relating the derived factors to the post-high-school activities and achievements of a representative sample of American youth. Our goal is not only prediction. Although certain kinds of predictions would be better with the original test scores, the smaller number of factors has many advantages, as can be seen in this volume and which we expect will be even clearer in a subsequent report on the criterion studies projected for next fall.

As has been pointed out in previous publications, Project TALENT is necessarily a group effort. For this reason we like to acknowledge all those individuals who make these research reports possible. The current staff at Project TALENT is listed on the inside back cover.

William W. Cooley
Pittsburgh, Pennsylvania
November 1, 1966

PREFACE

Teamwork is the hallmark of Project TALENT operations. Every member of the Project staff, past and present, contributed to this research effort.

I was inducted into this approach to measurement research by several professors in graduate school. Numerous friends provided critiques of aspects of this work.

The only sole responsibility I claim is for my stubborn persistence in certain methodological decisions which are "wrong" from the points of view of colleagues, and for some of the interpretations forced on the data. Fortunately, the measurement system was found to have strong internal structure that dominated the methods of analysis.

To my tutors, colleagues, and friends, to the subjects who provided the data, to the citizens who supported their collection and analysis, and to my patient wife I express my gratitude.

Paul R. Lohnes
Pittsburgh, Pennsylvania
November 1, 1966

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Chapter One

ORIGINS AND OUTLINES OF A THEORY OF PERSONALITY

I. TRAIT AND FACTOR PSYCHOLOGY

Educators are preoccupied with problems of personality, if we mean by personality the totality of behavior potentials and tendencies of a human being. The business of educators is the shaping of personality. The problems they encounter in their efforts to shape personality are multifarious. Although teaching has always been recognized as an art, educators in the twentieth century have gazed wistfully at the manifold accomplishments of applied science in other enterprises, and yearned for a science of education. Just enough progress has been made toward such a science to keep the hopes of educators alive, but advances in industrialism and social democracy have increased the demand for both quality and quantity of educational achievement at a pace which shrouds the real progress, so that a sense of the problems of education dominates the scene. What optimism there is has its basis in scientific and technological advances sponsored by federal and foundation funds for research and development activities.

The layman has little regard for the role of theory in science. What impresses him are the technological applications of science. Transference of this attitude may cause him to look for gadgets in the classroom as the signs of science in education, and not to look behind the gadgets for the theories that suggested and justified them. In fact, the gadgets are arriving in the classroom as real fruits of science. Our exploration of adolescent personality is going to emerge with assignments for computers in classrooms. The educator as a professional, however, needs to know the theories hidden behind the gadgets. If computer measurement systems are to be installed in schools to monitor personality development of students, diagnose problems and prescribe treatments, educators need to understand the theorizing about personality that such systems derive from. Educators who do not understand the technology that is appearing in schools are surrendering control to gadgets and are abandoning their professionalism.

Modern teacher training programs recognize that educators need theory by universally requiring the study of educational psychology. Usually educational psychology is compartmentalized in two courses, a human development course and a human learning course. This division stems from the natural occurrence of two principal problems for educational psychology, the problem of status and the problem of change. The problem of status is simply that educators require good descriptions of human beings at various stages of development. Achieving adequate descriptions of human beings as they exist at points in time and stages in development is the objective of personality theory. The problem of change is that educators need to know how to arrange desired changes in human status and how to understand and anticipate changes that occur without the sponsorship of the school. Achieving prediction and control of changes in human beings is the objective of learning theory. Personality and learning are not watertight compartments in educational psychology. Actually, there is so much seepage between them that they should be viewed as separate emphases, not separate entities. Our point is that today's educator requires both personality theory and learning theory in support of his daily efforts to understand children and to help them grow properly. In this monograph our emphasis is on the problem of how to describe human beings rather than on how to change them; therefore the words "personality theory" fit our undertaking.

All educators can benefit from possession of a sound and workable theory of personality, but such possession is indispensable to certain classes of educational specialists. Curriculum and guidance experts must work within the framework of a functional theory of personality if they are to work effectively. Such a theory provides a model of the student, in terms of which the curriculum expert can define objectives of education and training and specify evaluation procedures, and the guidance expert can assess students' potentials and problems.

Psychology affords many theories of personality. It might seem that educators have a wide field of choice. This is not really the case. Many of the current theories are too inexplicit and imprecise to be of use in education. They generate propositions which are neither scientifically verifiable nor practically applicable in an educational technology.

One approach to personality theory that presently affords degrees of comprehensiveness, explicitness, verification, and operationalism sufficient to warrant urgent claims on the attention of educators is known as trait and factor psychology, hereafter referred to as T-F theory. T-F theory is widely recognized as one of the great achievements of American psychology and as the undergirding of much of applied psychology. When the derivation of educational measurement procedures from T-F theory has been explained, the reader will recognize that this type of theory of personality is firmly entrenched in the ideological foundations of American education. Since T-F theory is the only type of personality theory that has generated an extensive technology of measurement of human capacities and dispositions, it is the inevitable choice of theory if one admits the need for measurement.

Educators do not all subscribe to the dictum that what exists can be measured, but since Edward L. Thorndike's pioneering days in educational psychology to the present it has become increasingly apparent and accepted that a science of education can only be built on objective measurement of human status and change. In 1928 Truman Lee Kelley voiced his version of this imperative.

> Thus, in the field of psychology, if a designation of some trait or capacity, as a category of mental life, is to be given serious consideration, it must be such as to reveal itself as a measurable difference in conduct, that is, as a measurable difference in the same individual at different times, or in different individuals at the same time.

The importance of quantification in science is undeniable, no matter how unpalatable the increasing quantification of psychology may be to some people. Progress in educational psychology depends upon increasing sophistication and generality for mathematical and statistical models, and these in turn require measurement inputs and generate measurement outputs as predictions. Those who view the human behavior system as too complex for mathematization need to realize that the more complex the system under study the more essential mathematical abstraction becomes. Kelley articulated the situation in human psychology as early as 1914.

> When a large number of factors, none of them of predominant importance, contribute to a total result, the human intellect, unaided, cannot compass their total significance and it is only by mathematical means that they can be summed and interpreted.

Two decades later Kelley discussed as a specific example of an educational variable that is widely accepted as an objective of social studies curricula the notion of "good citizenship," and spelled out the danger inherent in accepting such vaguely stated goals without measurement procedures for them.

> In so far as good citizenship is not quantitatively or qualitatively measurable by tests or the personal evaluation of associates, it is worse than no concept at all, as it distracts the attention from concern with attainable and cognizable outcomes. The moment it is possible reliably to appraise pupils upon this trait, it becomes possible to determine the efficacy of instruction as stimulating the trait; it becomes possible to choose between several types of instruction, or types of curricula, upon the basis of their excellence as developers of the trait. (Kelley, 1934)

Here Kelley speaks of the need for tests or personal evaluations, but before he reaches the end of this long book titled *Tests and Measurements in the Social Sciences* he becomes disillusioned regarding ratings by teachers as measurements and decides that the only hope for reasonable degrees of reliability and validity lies in standardized instruments.

> The development of objective measures of character traits is a fundamental necessity in the improvement of methods of character training...

It is rather sad to observe that Kelley's conclusion in 1934 that no effective measurement procedures existed for assessing many of the most valued characteristics of people remains true today. With respect to character traits as objectives of education the educational psychologist today can do little more than reiterate Kelley's somber injunction.

> It is futile to speak glibly of an education involving traits whose very existence in different amounts from pupil to pupil remains unknown.

Nevertheless, Kelley did possess a clear vision of the essential role for personality trait measurements in curriculum science. He required that "the status of school children be measured and the changes in status as correlated with changes in instructional techniques be experimentally determined," and concluded that "then and only then would one be in a position to formulate defensible and promising neoeducational doctrines of purpose, practice, and outcome." He spelled out in 1934 a set of functions for a school testing program and a plan for the division of labor between the teaching and assessment functions which we are still trying to realize in schools, and which is in fact a good statement of the functions we now want to expedite through a computer measurement system.

> (We) would emphasize these related uses of tests: (a) their use in the immediate facilitation of instruction of the pupils taking the test, (b) their use for the advancement of professional knowledge which will serve in the solution of various instructional problems, and (c) their use as instruments in any continuing, or fairly long time, guidance program. We would also emphasize that although every teaching or learning process implies a program of testing, it requires a separate focus of attention and frequently an additional and definite act to realize this program. To assume that the testing function is realized as soon as the teaching purpose is defined and content presented is education by faith. We specifically deprecate an educational program which does not involve some definite and adequate appraisal of pupil growth and accomplishment.

The continued need for emphasis on measurement as an integral element in curriculum science can be inferred from this contemporary plea for more attention to curriculum research on the part of psychologists.

> The area of the greatest need and the least current knowledge is that of educational objectives and the contents of the educational program. Research is required to develop a sound, factual basis for describing objectives. Each objective should be defined in terms of the specific procedures to be used in evaluating the student's progress with respect to it. It is time that educational

> psychologists take an active part not only in the theoretical and laboratory aspects of secondary education, but in practical applied work aimed directly at improving the total educational program in our secondary schools. (Flanagan, 1963a)

Elsewhere, the same author discusses the need from the standpoint of the national welfare.

> To evaluate the quality of an educational program requires the comprehensive measurement of results. In this age of science and research it is astounding to find that for one of the largest expenditure items in state and community budgets there is virtually no audit of quality and no local research program to improve the effectiveness of the system. If an industrial organization were to operate on this basis, it would have little chance of survival. (Flanagan, 1964)

The reader is of course aware of the tremendous amount of testing done in today's schools, and he may wonder if a straw man is being beaten. The author's contention is that for the most part testing results are not being used for the functions Kelley and Flanagan describe. That tests are in such widespread circulation testifies to the persuasiveness of the T-F theory from which they derive. On the other hand, the widespread criticism of testing testifies to confusion regarding the purposes of all this testing and a sense of the waste that occurs where tests are administered for ritualistic ends. There is indeed enough testing going on, if not too much. What is lacking is a systems approach to the utilization of test results in the discharge of the functions for testing that Kelley and Flanagan describe. We now have good measurement instruments (although we certainly need improvements in them), but we are just beginning to design good systems into which to incorporate them. Perhaps the development of adequate systems had to await the availability to schools of the large digital computer. It is impossible to visualize an efficient system for test utilization in schools today which would not be computerized. Thus we anticipate a computer measurement system in which our theory of adolescent personality would find a practical application.

We have argued that T-F theory is important to the educator because it provides him with an adequate set of concepts and language for describing students, and because the educational measurement systems which are assuming increasing numbers of functions in schools are derived from and depend upon T-F theory. Another reason the educator must attend to T-F theory is that the great bulk of the educational research which is published derives from this ideological position. Very seldom does one find a research report in which the predictor variables or the criterion variables, or both sets of variables, are not measured traits of personality. The fact is, traits of ability and motive so thoroughly permeate educational research that they are commonplaces and one seldom reflects on the commitment to T-F theory involved. Nevertheless, the commitment is implicit. As an example, consider the monumental survey of educational deprivation of children in minority groups published by the U. S. Office of Education under the title *Equality of Educational Opportunity* (Coleman, 1966). For this survey 640,000 students in a national probability sample were tested, half of whom belonged to minority groups. Statistical analyses revealed that children from minority groups suffer substantial impairments in their growth on intellectual achievement traits, and related these losses to subnormal educational provisions for them. This study was ordered by Congress, and may be expected to have enormous social impact in the years ahead. Apart from its social significance, it is good sciencing. It advances our knowledge of the educational conditions which stimulate or retard intellectual growth considerably. Without the undergirding of a T-F theory of human personality this study would have been impossible.

If T-F theory is so entrenched in the ideology of American education, what urgency can there be about the research reported in this monograph? Actually, there is great need for clarification of T-F theory in educational psychology. Trait and factor theory is a generic term for a family of specific theories of personality. These theories have much in common, but they also have enough differences among them to cause a great deal of confusion. Each specific theory has sponsored special trait concepts of its own and then devised measurement instruments to operationalize them. The resulting proliferation of tests and inventories

has had its positive aspect, in that it has provided researchers and educators with a marvelous variety of assessment procedures, but the bad aspect has been the Babel of concepts disseminated by the manuals accompanying the tests and inventories.

The situation in T-F theory is part of a situation that seems to threaten or at least to impede the progress of psychology in general. Succinctly, psychology is burdened with too many personal theories. There are about as many theories as there are productive research psychologists. It seems that a psychologist can't hold his head up if he doesn't have his own theory. Most research psychologists work on problems of application of psychological principles to specific circumstances, yet many of these workers seem to be convinced that general theories can be evolved from relationships observed among variables in their special bailiwicks. Educational psychology, as one applied field, badly needs more organization, more synthesis, more unity, and less personalism. We need some provisional closures in a general educational psychology. We need a common body of doctrine as a base from which to develop individualized explorations at the cutting edge. The need comes from the pressing social demands for a practice of educational psychology. Some critics say that there isn't enough psychology to warrant a practice yet, but the real case is that personalism screens the availability of sufficient trustworthy generalizations about human personality and learning to form a core of doctrine.

A general descriptive theory of adolescent personality for educational psychology is the objective of this monograph. This will be a fairly simple theory, incorporating a small number of concepts and of generalizations. The theory to be presented is definitely not the personal creation of the author, and he hopes that it will not be seen as such. It represents an effort to sift from the T-F literature the elements on which widespread agreement exists or might be organized. It is operationalized through batteries of measurements that were assembled by a responsible team of investigators, with the advice of an impressive committee of psychometricians, as state-of-the-art batteries in 1959. It is demonstrated on data from the largest and most representative sample of

American adolescents ever measured with complete state-of-the-art batteries, the 1960 Project TALENT sample. The details of the theory have been defined by standard and objective analytic techniques, not of the author's invention. Every major concept and generalization in the theory already exists in the ordinary language of educational psychology. There are no major surprises. If there is a contribution it resides in the consolidation of a position which could be widely adopted as a provisional doctrine on descriptive adolescent personality theory and a provisional core of measurement procedures for secondary education. The simplicity of the theory should make it possible for most educators to learn its rubrics. We can't afford too much detail in a general theory because we must teach it widely. This is not a professors-only game. The need for a provisional doctrine on adolescent personality is greater among schoolmen in the field than it is in the ivory towers.

II. PROJECT TALENT

John C. Flanagan conceived and began planning Project TALENT over a decade ago. His wartime experiences at the head of the Aviation Psychology Program of the Army Air Forces, in which he and his colleagues developed personnel procedures based on standardized tests that produced substantial savings in lives and equipment and marked improvement in the flow of aircrewmen through training to combat, had persuaded him that "a greater improvement can be gained in effectiveness in the activity for which the individual was selected and trained by research on selection and classification than by research on training procedures." (Flanagan, 1948) He was convinced that the same type of research on the measurement and deployment of individual differences in civilian life could reduce the waste of human talent in the economy and improve the educational and vocational decisions of young people. In 1959 the U. S. Office of Education undertook to support Flanagan's vision of a national census of the abilities and motives of high school youth. The cost of the project by then current standards was large enough to make the contract a first plunge on the part of the federal government into large-scale investment in educational research packages, and a harbinger of

things to come. In signing the contract, Commissioner Derthick said of the project that "it is an attempt to determine why so much of the nation's human potential is lost and what schools, counselors and parents can do to reduce this loss." (Flanagan, 1962a) The objective of the study was stated in three questions. "What is talent? How can it be developed? How can an individual make the best use of his talents?" The studies of this monograph were foreseen by the authors of the design. "Available knowledge is particularly deficient with respect to the interrelation patterns of aptitudes, preference, interests, socioeconomic factors, and motivational factors."

The basis for the design of the study was a multifactor theory of human talent. The authors spoke of general intelligence as an over-simplified concept of the nature of talent. They claimed that each person possesses his own unique, persistent pattern of aptitudes, and defined talent as this "unique pattern of potentials for learning to perform various types of activities important in our culture."

In 1960 a probability sample of about 5 per cent of the nation's high schools was drawn, and almost 450,000 students attending the schools in the sample were administered two full days of tests and inventories. Included in the thousands of items the students responded to were the elements for 60 different abilities scales and 38 motives scales. These 98 scales represent the sources of information about adolescent behavior traits which are analyzed into a trait and factor theory of adolescent personality in this volume. The Project TALENT staff is conducting follow-up studies at five-year intervals on the subjects, in order to collect information about educational, vocational, and other life adjustments which can be related by statistical analyses to the 1960 measurements. In special studies thousands of the youth in the original sample are retested at intervals to provide data on development and change in personality traits. Several thousand twin pairs in the sample are being studied with special intensity because of the opportunity they provide for testing genetic hypotheses. All these continuing research activities contribute to a remarkable opportunity for discovering the predictive validities of the 1960 measures of capacities and

dispositions. A recent volume, *Project TALENT One-year Follow-up Studies* (Flanagan et al, 1966) reports the first in a series of such prediction studies.

A full description of the tests and inventories and the procedures by which they were assembled is contained in *Design for a Study of American Youth*. (Flanagan,1962a) The 60 abilities tests and 38 motives scales are listed in Tables I.I and I.2 to give the reader an idea of the comprehensiveness of the batteries. The fuller development of the measurement program in the abilities domain fairly reflects the relative states of the arts of abilities testing and motives appraising. The author cannot overstate the care and skill with which the original staff of Project TALENT combed the literature of psychometrics and educational measurement, selecting the best of the known item forms for the known measurement traits, and wrote new tests and inventories truly representative of the state of the art of measuring educationally relevant traits with group paper-and-pencil methods. The values claimed for the descriptive theory of adolescent personality organized in this monograph stem largely from the successes of the original staff of scientists at Project TALENT. Included in this group were John C. Flanagan, John T. Dailey, Marion F. Shaycoft, William A. Gorham, David B. Orr, and Isadore Goldberg.

III. HISTORY OF MENTAL MEASUREMENT

The study of individual differences is as old as any aspect of the study of man. Mathematical approaches to human differences go back at least to Quetelet (1796-1874), who first applied the normal curve to observed human variability.[1] One Englishman, Francis Galton (1822-1911), however, deserves recognition as the founder of trait and factor psychology. Galton devoted much of his life to the measurement of physical and mental traits of people, established a laboratory for this purpose, and established a style of empirical research on correlation of traits which

[1] We are fortunate that Anne Anastasi has given us an excellent collection of source readings in the history of trait psychology in her paperback book, *Individual Differences*, N.Y.: Wiley, 1965.

Table I.I

60 Abilities Domain Variables

	Mnemonic	Code	Name of Test
1	SCR	R-101	Screening
2	VOC	R-102	Vocabulary
3	LIT	R-103	Literature
4	MUS	R-104	Music
5	SST	R-105	Social Studies
6	MAT	R-106	Mathematics
7	PHY	R-107	Physical Sciences
8	BIO	R-108	Biological Sciences
9	SCA	R-109	Scientific Attitude
10	AER	R-110	Aeronautics and Space
11	ELE	R-111	Electricity and Electronics
12	MEC	R-112	Mechanics
13	FAR	R-113	Farming
14	HEC	R-114	Home Economics
15	SPO	R-115	Sports
16	ART	R-131	Art
17	LAW	R-132	Law
18	HEA	R-133	Health
19	ENG	R-134	Engineering
20	ARH	R-135	Architecture
21	JUR	R-136	Journalism
22	FOT	R-137	Foreign Travel
23	MIL	R-138	Military
24	ACC	R-139	Accounting
25	PRK	R-140	Practical Knowledge
26	CLE	R-141	Clerical
27	BIB	R-142	Bible
28	COL	R-143	Colors
29	ETI	R-144	Etiquette
30	HUN	R-145	Hunting
31	FIS	R-146	Fishing
32	OUT	R-147	Outdoor Activities (other)
33	PHO	R-148	Photography
34	GAM	R-149	Games (sedentary)
35	THR	R-150	Theater and Ballet
36	FDS	R-151	Foods
37	MIS	R-152	Miscellaneous

Table I.I (continued)

	Mnemonic	Code	Name of Test
38	MMS	R-211	Memory for Sentences
39	MMW	R-212	Memory for Words
40	DSW	R-220	Disguised Words
41	SPL	R-231	Spelling
42	CAP	R-232	Captialization
43	PNC	R-233	Punctuation
44	USG	R-234	English Usage
45	EXP	R-235	Effective Expression
46	WDF	R-240	Word Functions in Sentences
47	RDG	R-250	Reading Comprehension
48	CRE	R-260	Creativity
49	MCR	R-270	Mechanical Reasoning
50	VS2	R-281	Visualization in Two Dimensions
51	VS3	R-282	Visualization in Three Dimensions
52	ABS	R-290	Abstract Reasoning
53	ARR	R-311	Arithmetic Reasoning
54	MA9	R-312	Introductory Mathematics
55	ADV	R-333	Advanced Mathematics
56	ARC	R-410	Arithmetic Computation
57	TBL	R-420	Table Reading
58	CLR	R-430	Clerical Checking
59	OBJ	R-440	Object Inspection
60	PRF	A-500	Preferences

Table I.2

38 Motives Domain Variables

	Mnemonic	Code	Name of Scale
1	MEM	A-001	Memberships
2	LEA	A-002	Leadership Roles
3	HOB	A-003	Hobbies
4	WOR	A-004	Work
5	SOC	A-005	Social
6	REA	A-006	Reading
7	STU	A-007	Studying
8	CUR	A-008	Curriculum
9	COU	A-009	Courses
10	GRA	A-010	Grades
11	GUI	A-011	Guidance
12	NSO	R-601	Sociability
13	NSS	R-602	Social Sensitivity
14	NIM	R-603	Impulsiveness
15	NVI	R-604	Vigor
16	NCA	R-605	Calmness
17	NTI	R-606	Tidiness
18	NCU	R-607	Culture
19	NLE	R-608	Leadership
20	NSC	R-609	Self-confidence
21	NMP	R-610	Mature Personality
22	IPS	P-701	Physical Science, Engineering, Mathematics
23	IBS	P-702	Biological Science, Medicine
24	IPU	P-703	Public Service
25	ILL	P-704	Literary, Linguistic
26	ISS	P-705	Social Service
27	IAR	P-706	Artistic
28	IMU	P-707	Musical
29	ISP	P-708	Sports
30	IHF	P-709	Hunting, Fishing
31	IBM	P-710	Business Management
32	ISA	P-711	Sales
33	ICO	P-712	Computation
34	IOW	P-713	Office Work
35	IMT	P-714	Mechanical, Technical
36	IST	P-715	Skilled Trades
37	IFA	P-716	Farming
38	ILA	P-717	Labor

rapidly developed into the psychometric movement. He discovered the regression effect in correlation of parent-child traits, which is the tendency toward the mean in the inheritance of traits. One of his students, Karl Pearson (1857-1936), put the correlation coefficient in its modern algebraic form. In 1890 Galton stated the program for predictive validity studies of traits.

> One of the most important objects of measurement... is to obtain a general knowledge of the capacities of a man by sinking shafts, as it were, at a few critical points. In order to ascertain the best points for the purpose, the set of measures should be compared with an independent estimate of the man's powers. We thus may learn which of the measures are the most instructive...

Galton invented the questionnaire, a device on which Project TALENT's follow-up studies depend. His comments in 1908 on requirements of mental tests and questionnaires have a delightful straightforwardness.

> It is by no means easy to select suitable instruments for such a purpose. They must be strong, easily legible, and very simple, the stupidity and wrong-headedness of many men and women being so great as to be scarcely credible.

In the United States, James McKeen Cattell (1860-1944) had established a laboratory for study of individual differences before the turn of the century. In the last years of the nineteenth century American psychology became dominated by the school of structuralism, which was transplanted to the U. S. from Germany by Wundt's student, E. B. Titchener (1867-1927). The concern of the structuralists was with questions about what the basic mental processes are, how they are interrelated, and why they structure experience as they do, problems which are very central to psychology today, but their primary method was introspection, giving their writings a subjectivity which is far from modern. Fortunately, a native American school of psychology arose to challenge structuralism, and to sponsor an objective empiricism in research. Functionalism grew from the work of William James (1842-1910), John Dewey (1859-1952), James Angell (1869-1949), and Harvey Carr (1873-1954). James urged that mind was to be viewed as a process, not as a collection of mental

states, and fostered the testing of ideas by their consequences we know as pragmatism. In functionalism the subject of psychology became mental activity, which Carr defined as "the acquisition, fixation, retention, organization and evaluation of experiences, and their subsequent utilization in the guidance of conduct." (Carr, 1925) One needs only to note the similarity with J. P. Guilford's list of mental processes in the operations dimension of his structure of intellect model (cognition, memory, divergent thinking, convergent thinking, evaluation) to establish the modernity of Carr's view of psychology. In fact, as one recent critique of functionalism concluded, both the mental testing movement and current theories of human learning owe so much to functionalism that it can be said to have been "absorbed into contemporary psychology." (Chaplin and Krawiec, 1965)

In his efforts to develop a psychology of human abilities, Cattell concentrated on objective consequences of mental processes and ignored conscious content, placing himself close to the functionalist school, although he was never formally a member of it. In an article titled "Mental Tests and Measurements" (this in 1890), Cattell laid out the program for researches such as Project TALENT.

> Psychology cannot attain the certainty and exactness of the physical sciences, unless it rests on a foundation of experiment and measurement. A step in this direction could be made by applying a series of mental tests and measurements to a large number of individuals. The results would be of considerable scientific value in discovering the constancy of mental processes, their interdependence, and their variation under different circumstances.

One of the giant steps in mental trait theory was taken by Charles Spearman (1863-1945) when he announced his two-factor theory of intelligence in 1904, <u>before</u> Alfred Binet and Theophile Simon's 1905 publication of their new intelligence scale. Spearman's apprehension that a theory of mental organization could be tickled out of intercorrelations among tests by mathematical means was to flower into the vast literature of factor analysis. He foreshadowed a great deal when he advocated in 1904 a "correlational psychology."

A particular emphasis in the history of T-F psychology has been the study of effects of heredity on mental traits. Karl Pearson pioneered the large sample survey method of research with his 1904 study of inheritance of mental and moral traits. Incidentally, in the report of that study Pearson struck a blow for the validity of description as a goal of science, and also for the importance of applied science.

> ...the mission of science is not to explain but to bring all things, as far as we are able, under a common law. Science gives no real explanation, but provides comprehensive description. In the narrower field it has to study how its general conceptions bear on the comfort and happiness of man.

In his report Pearson articulated what has persevered as a rather extreme British position on inheritance of traits.

> It is the stock itself which makes its home environment; the education is of small service unless it be applied to an intelligent race of men.

Only a year later, in 1905, the founder of educational psychology in America, Edward Lee Thorndike, published the first quantitative twins study. At that time he expressed a balanced opinion on heredity.

> To the real work of man for man--the increase of achievement through the improvement of the environment--the influence of heredity offers no barrier. But to the popular demands for education and social reforms it does.... In the actual race of life, which is not to get ahead, but to get ahead of somebody, the chief determining factor is heredity.

The flowering of the mental measurement movement, both as science and as technology, from these origins need not be traced here. Obviously it has flowered into one of the great decorations of modern psychology, and with full respect to its English pioneers, America has been the place of its greatest fecundity and public acceptance.

IV. FACTOR ANALYSIS

A particular preoccupation in the mental measurement movement has been the search for explanatory concepts for observed intercorrelations

among measured traits. If Pearson was satisfied that correlation coefficients rendered adequate description of the actual interdependencies among aspects of human behavior, most of the researchers using his coefficient came to the conclusion that they could not accept correlations as the final analysis of their measurement data, simply because there were too many of them. A study of two behavior traits yields only one correlation, a study of three traits yields only three correlations, but even a study of ten traits yields an unwieldy set of 45 correlations. If one studies 100 behavior traits simultaneously (which is the scope of the Project TALENT inquiry), the matrix of intercorrelations contains 4950 different correlations. It became apparent that the matrix of correlations itself did not provide sufficient reduction of the data. Analysis of the correlations among measured traits (which we will now call surface traits) to produce or test hypotheses about underlying, latent traits of personality (which we will call source traits, or factors) was required. Charles Spearman innovated such analysis in 1927 with his tetrad equation approach to demonstrating that every surface trait of ability can be explained by means of a general intellectual factor, _g_, which is common to all abilities, and a special factor measured only by the specific test. A year later Truman Kelley used the tetrad equations method to locate five group factors, or factors with partial generality, in addition to the _g_ factor, thus introducing the notion of a source trait common to some but not all the tests in a battery. A scant three years after this, in 1931, Louis L. Thurstone introduced his Primary Mental Abilities solution, in which all the common factors are group factors, and there is no _g_ factor. Then in 1933 Harold Hotelling provided a firm mathematical model for factors in the principal components analysis, and the stage was set for several decades of steady progress in power and popularity of factor analysis.

The research reported in this monograph is for the most part factor analytic research, and the theory of adolescent personality put forward is a factor theory. Our view of what a theory of personality consists of is precisely aligned with that set forth by Hall and Lindzey in their survey of such theories.

> Thus, we submit that personality is defined by the particular empirical concepts which are a part of the theory of personality employed by the observer. Personality consists concretely of a set of values or descriptive terms which are used to describe the individual being studied according to the variables or dimensions which occupy a central position within the particular theory utilized. (Hall and Lindzey, 1957)

This view emphasizes that personality is something constructed by the scientist as an amalgam of his observations and his ideas about how to order observations. Personality is attributed to a subject by an investigator; it is not discovered in the subject by the investigator. When researchers state theoretical propositions about personality, they are not seeking to reveal the "true dimensions" of personality, but rather to organize their knowledge of personality as effectively as possible. Since "a theory is a set of conventions created by the theorist" (*op. cit.*), a theory is not true or false, but is useful to a degree determined by "how efficiently the theory can generate predictions or propositions concerning relevant events which turn out to be verified." (*op. cit.*) The two facets of a theory are that it is a description system and that it is a prediction system. The verification of predictions derived from the theory justify the descriptions rendered of natural phenomena to some extent, but the comprehensiveness and relevance of the descriptions are also germane, as are criteria of logic and parsimony. We also agree with Hall and Lindzey that "all matters of formal adequacy pale alongside the question of what empirical research is generated by the theory" (*op. cit.*), and we hope that the T-F theory proposed here will come off well on this score.

Anastasi has given succinct expression to the characterization of factor analysis we endorse.

> Factor analysis is not a device for discovering basic, immutable units of behavior but a technique for introducing order into a mass of otherwise unmanageable facts. (Anastasi, 1965)

Kelley put the matter eloquently some years ago.

> There is no search for timeless, spaceless, populationless truth in factor analysis; rather it represents a simple, straightforward problem of description in several dimensions of a definite group functioning in definite manners, and he who assumes to read more remote verities into the factorial outcome is certainly doomed to disappointment. (Kelley, 1940b)

Godfrey Thomson took the measure of factor analysis in 1939.

> There is a strong natural desire in mankind to imagine or create, and to name, forces and powers behind the facade of what is observed, nor can any exception be taken to this if the hypotheses which emerge explain the phenomena as far as they go, and are a guide to further inquiry. That the factor theory has been a guide and a spur to many investigators cannot be denied, and it is probably here that it finds its chief justification.

Factor analysis assists the researcher in his efforts to organize and summarize his data. First and foremost, factor analysis is a heuristic procedure, capable of discovering principles of classification for observations. It is an example of the kind of inductive logic which, when taught to computers, enables artificial intelligence to extend and supplement human intelligence in the advancement of science. We need to recognize the heuristic capability of factor analysis, but we also need to perceive clearly that what is discovered by the method is scientific constructs that exist only in the realm of ideas. Cyril Burt expounded this truism in 1949, in a review of factor analysis for the *British Journal of Educational Psychology*.

> A factor is not to be regarded as a simple, isolated, causal entity, much less as an elementary capacity, inherited as such, and capable of spontaneous maturation, regardless of environmental influence.... A factor is primarily a principle of classification; it is thus not so much a concrete cause as an abstract component.

Just as T-F psychology is a generic term for a family of specific theories, factor analysis is a generic term for a family of specific procedures. Before we could do factor analysis research on the Project TALENT data we had to make difficult methodological choices. The

technical specifications of the methods we decided upon are reviewed in Chapter Two. The most general and noteworthy characteristics of our research methods will be exposited here, in relation to a brief history of the special tradition in trait and factor psychology from which they derive, and particularly of the career of the leading spokesman for that tradition.

V. TRUMAN LEE KELLEY

Truman Lee Kelley (1884-1961) trod the center stage of educational psychology in America for nearly 50 years researching, teaching, and writing from the eminences of Columbia, Stanford, and Harvard. His leadership was as pervasive as it was enduring, spanning the fields of measurement, statistics, and personality theory. He did as much as any man to establish the vision and launch the program of a hardnosed, quantitative science of education. Among his manifold theoretical and practical accomplishments one commitment stands forth in prominence, manifesting itself everywhere in his work, and that is his commitment to the principle of "modes of mental functioning which are independent of other modes." (Kelley, 1940c) It was his firm and lasting conviction that the "essential traits of mental life" (his title for a 1935 book) would have to be uncorrelated among themselves if they were to have maximum scientific value and practical utility. He argued for this principle repeatedly, worked to derive the necessary methodology of orthogonal factor analysis, and applied the principle consistently in his measurement researches. He held to the principle stubbornly, despite the impossibility of computing large-scale orthogonal solutions with the crude computing machinery of his time, and despite the total resort of other measurement psychologists to correlated, or oblique, factor solutions, following the direction taken by L. L. Thurstone with his famous Primary Mental Abilities solution.

Kelley's 1928 book, *Crossroads in the Mind of Man*, unfolded his vision of an applied psychology based on uncorrelated traits.

> The advantages of measures of traits which are independent of the other traits involved are so great for all problems of guidance, classification, and education that they are, in truth, at the foundation of a new psychology which the future is to build.
>
> The determination of what are the independent mental traits, of what are their laws of functioning, and of what adult activities demand them should, for the sake of eugenics, be a prenuptial concern; should, for efficient nurture, be a matter for continual note in the rearing of the individual from the age when his food-getting and other instinctive responses no longer circumscribe his daily life to the close of his formal education; should, for social efficiency, be a determining influence in the choice of a life vocation; and should, in national life, be an intimate issue in establishing comity between nations.

Psychology is to find application to all of man's affairs, and the elemental constructs of psychology are to be uncorrelated traits of personality. Kelley was always known for his insistence on the strong part genetic inheritance plays in determining personality traits (see his 1926 book, *The Influence of Nurture Upon Native Differences*, as an example of his research on the genetic-environment problem), yet he maintained a constant optimism regarding the opportunities for improvement of man's lot through the proper understanding of and deployment of human traits. In 1940, as the nation stood on the verge of a global war that would tax its human resources to the limit, Kelley titled a book *Talents and Tasks: Their Conjunction in a Democracy for Wholesome Living and National Defense*. He was serious about this title.

> The democratic problem that we set is so to utilize the talents of our differentially endowed and trained citizens as to maximize their satisfactions and their social productivity.

He discussed the successes trait psychology had in World War I, when the Army was persuaded by E. L. Thorndike to employ a system of officer candidate allocation based on "trait rubrics because of their presumptive value in determining fitness for essential duties." (Kelley, 1940)

As a matter of fact, the program of this 1940 book was too visionary, for its time at least. Kelley wanted to apply the recently developed method of canonical correlation (Hotelling, 1935) to maximize the agreement between "welfare" traits (the system of individual needs) and "utility" traits (the system of social press). What he had in mind was a nationwide realization of the utilitarian principle of the greatest good for the greatest number through a rational matching of men to vocations. Nevertheless, he did make contributions himself to the matching of men to military assignments during World War II, and his students, particularly John C. Flanagan, contributed heavily in this area.

No application of mental trait theory interested Kelley more than the possibilities for educational and vocational guidance of youth. As early as 1914 he was writing on the subject, in a book titled *Educational Guidance*.

> That a fitting distribution of human talent is a task of unmeasured intricacy is apparent, but the peculiar service thereby rendered to groping humanity makes the solution worthy the greatest effort.

In 1909 the founder of vocational guidance, Frank Parsons, spoke of the young person's need for understanding of himself, for knowledge of occupations, and for "true reasoning" in relating the two. Kelley's concept of the guidance process in 1914 was quite close to that of Parsons.

> The two chief factors entering into the problem of efficient guidance are, first, a correct understanding of the demands of prospective tasks and, second, an accurate valuation of the ability of the person in question to meet these demands. These two main elements of the problem may be stated as requiring an analysis of the individual to determine his characteristics, and an analysis of the needs of the situation to see to what extent the individual meets these needs. This is a general statement of the problem applicable to all kinds of guidance.

It has become fashionable in some quarters to deride this program for vocational guidance as a naive, peg-in-the-hole program. Undoubtedly some young people need therapeutic experiences before they can learn to do "true reasoning" relating their personal characteristics to the requirements of vocations. Nevertheless, it is possible that the great majority of young people would benefit enormously from a program of vocational exploration within a framework of self appraisal, such as Parsons and Kelley advocated. Perhaps the real reason that many counseling psychologists have denigrated this program is that it is too demanding of counselor expertise. This program requires that the counselor possess a huge reservoir of vocational information, that he be a paragon in the interpretation of mental measurements, and of course that he be a master teacher. If this has been a practically impossible program to implement in the past, the presence of the large digital computer in the guidance environment promises to swing the balance in the counselor's favor in the future, by providing him with instantaneous retrieval of vocational information and powerful interpretations of mental measurements. He will not have to masquerade as either an information machine or an analytic machine, neither of which he wants to pretend to be, and will be free to concentrate on helping youngsters to ask appropriate questions of the computer information and measurement system, and helping them to assimilate the answers they get.

The analytic procedures employed by a computer measurement system in the interpretation of trait profiles of students will have to be multivariate statistical procedures which only artificial intelligence can employ with the volume and speed the counseling program will require. In 1914 Kelley anticipated the role of multivariate procedures in guidance.

> As success usually depends upon several factors, partial correlation and the regression equation method are essential in the evaluation of data.

One of Kelley's most important methodological contributions was to urge and demonstrate the appropriateness of Hotelling's principal components method of factor analysis as an educational research tool.

In 1934, just one year after Hotelling published his method, Kelley published a principal components solution for a set of eight ratings and eight tests in a hypothetical citizenship syndrome. Pointing out that the relations among the 16 surface traits were "quite beyond the mind to picture," he phrased the following research question.

> To what extent are the eight traits as judged independent one of another, or if not independent, to what extent can independent traits, eight or less in number, be used to characterize the same children, and how are these new traits related to the eight upon which judgments were made?

In his discussion, Kelley emphasized the parsimony of the principal components solution as a measurement set involving no covariance parameters. Elsewhere he was to state the value of parsimony in research variables clearly.

> If two variables are correlated it is experimentally impossible to hold one variable constant without limiting the range of the second, and if, in the field of mental relationships, two traits are correlated it is impossible to think of the functioning of the one independent of the other. For self-appraisal or for the understanding of others, independent mental abilities must be thought of whenever possible. (Kelley, 1940a)

Kelley was aware that there is an infinity of orthogonal factor solutions for any correlation matrix, but he argued that the principal components were especially worthy because the major components maximized the extraction of variance from a battery by a subset of factors and produced source traits "in which there are glaring individual differences, not trivial ones." (Kelley, 1940b)

Finally, we discover in Kelley's 1940 Presidential Address to the Psychometric Society, titled "The Future Psychology of Mental Traits," a complete and compelling set of standards for a factor theory of adolescent personality, standards which have guided the research effort reported in this monograph.

> There are certain fundamental principles which should influence our selection (of derived measures):
>
> The original variables should be wisely chosen and weighted so as to encompass the life situations which it is desired to explain psychologically.
>
> The factors comprising the final set should be uncorrelated.
>
> These factors should be ordered for magnitude; this ordering, if the original variables have been wisely chosen and weighted, is also an ordering for importance....
>
> The factors comprising the final set should be as stable as possible with changes of age, thus avoiding new factors and new interpretative devices as growth takes place.
>
> As a final practical guide the final factors should be determined with high precision and with low time, administrative and scoring cost. (Kelley, 1940a)

Truman Lee Kelley had an amazing vision, but he never commanded the financial resources or the necessary tools (scoring machines and computers) to test his vision on a crucial research. It remained for one of his students, John C. Flanagan, to organize the financial resources on the threshold of a decade in which document readers and computers were to become adequate to the tasks, and to launch Project TALENT as the crucial research. We hope Kelley knew, in his final year, that the program of research in trait and factor educational psychology he had visualized was underway at last.

Flanagan began his career in psychometrics with a doctoral dissertation in 1934, written under Kelley's guidance, in which he reported a principal components factoring of the Bernreuter Personality Inventory. Two other members of his doctoral committee were Gordon W. Allport and Phillip J. Rulon. In his dissertation, Flanagan stated a set of standards for a trait and factor theory, also.

> The ideal theory of personality would:
>
> 1. Define its elements without ambiguity and in terms of behavior.
> 2. Be founded on extensive and accurate observations.
> 3. Consist of basic elements which are independent.
> 4. Provide a simple explanation of the maximum number of well-established facts.
> 5. Have the maximum predictive value. (Flanagan, 1935)

In 1952, in his own Presidential Address to the Psychometric Society, Flanagan expressed his conviction that psychology needs to devote a great deal of attention to studying human beings in their natural environments, and stated some principles for such studies. The present author strongly endorses this position, and sees Project TALENT as an example of such ecological psychology.

> The first (principle) is a preference for studying the problem, at least initially, in its natural or real setting rather than in an artificial or laboratory setting. .... The second principle proposed in designing the study is the systematic collection of a large representative sample of events or behaviors of the type being studied.
>
> Unusual effort and skill are required to discover and describe the fundamental relationships which are concealed within the large mass of the initial data. All of the tricks of multivariate analysis including factor analysis, partial correlation, and discriminant analysis will have to be used for effective handling of these problems. (Flanagan, 1952)

Later, Flanagan was to spell out a set of principles for the application of trait and factor psychology to problems of manpower conservation which are precisely the principles we would have govern the application of our Project TALENT researches in a computer measurement system for schools.

1. The multi-dimensional aptitude classification test approach is essential to the effective use of manpower resources.

2. In order for the students to make effective use of their talents they must have a comprehensive and precise description of these talents.

3. The individual should be described in terms of the extent to which he has the specific abilities required for a given occupation, or the necessary aptitudes to develop these abilities.

4. The descriptive categories should be as independent of each other as possible. ....

6. Efficient statistical procedures should be used to determine the relative appropriateness of the individual's talents for various occupations which he might choose. (Flanagan, 1963b)

VI. OUTLINES OF A THEORY

Having sketched the tradition in trait and factor psychology from which this research derives and acknowledged the standards it attempts to meet, we turn now to the general outlines of the theory itself. We have seen the sources of the *a priori* value judgments that established the general form of the theory before any research was done. These values which shaped the theory are orthogonality of factors, separation of the domains of abilities and motives, simplicity of factor structures, hierarchical structures, and ease of computation of factor scores. Objective analytic procedures executed by the computer created the details of the theory within the forms dictated by these prior values.

The insistence on orthogonality is going to trouble readers who are mindful that most of the major factor theories in the literature including those of Thurstone, Guilford, and Cattell, involve oblique solutions. There has been a presumption among many psychologists that orthogonal factors could not be satisfactory in the area of interpretability and construct validity. The chief rebuttal is that the factors in both domains of measured adolescent personality produced by this

research appear to have strong construct validities and to be unambiguously interpretable. However, this interpretability could no doubt be further improved by oblique rotations that would clean up the structures more than varimax has, so the argument for orthogonal solutions continues to be based on their parsimony. The trouble with an oblique structure is that the correlations among the factors require explanation, so that the scientist has to generate explanations of explanations. The result is a hierarchical personality structure in several levels, in which factors at a given level explain the correlations among the factors at the next lower level and are in turn explained at the next higher level. The elaboration that evolves may be interesting but it is not parsimonious. It is possible for a solution in terms of independent factors at one level of abstraction to accomplish as much explanation and prediction as a hierarchical solution with several levels at much less cost in conceptual complexity. As we shall see, factors at one level need not be all of the same degree of generality. The author contends that the unsatisfactoriness of previous efforts to establish orthogonal structure T-F theories stems primarily from the inadequate samples of variables and subjects available to the investigators.

In the present theory the locus of orthogonality of the factors of a domain is within a subpopulation composed of students of a single sex and a single grade in high school. This theory has attributed the important differences between sexes and between grades on the measurement variables to parameters of a linear model, so that there is a constant effect for sex and a constant effect for grade for all members of a particular sex-grade subpopulation. Chapter Seven reports these constants for each sex and for grades nine and twelve, for the 98 surface traits and for the 22 factors of the combined domains. There are some surprises, but in general these systematic differences are pretty much what educators would expect them to be. By actual computation, factor scores for a random sample from a given sex-grade subpopulation are shown to be uncorrelated. It is also shown by actual computation that the small correlations among factors that occur when analysis is based on a random sample from all the subpopulations are a result of correlated subpopulation means and are predictable from the

means. Empirical evidence is presented that tends to justify the underlying assumption of a common correlation matrix for the surface traits in the subpopulations.

We define a trait as an enduring pattern of behaviors which is exhibited by many people, but in varying degrees. We describe human personality as a system of traits, so that a personality is the overall organization of the enduring patterns of behaviors exhibited by a person. What characterizes a person as an individual, different from every other individual, is not the elements of his personality so much as the unique profile of degrees of intensity of those elements. In this theory, the traits which are the elements of personality are common to many people, but are developed in different people to different degrees. These degrees of strength or weakness of a trait in different people are measurable, so that the trait profile which characterizes a particular personality can be represented in scientific research by a set of scores. This approach to defining personality in terms of common measurement traits was exposited by Gordon Allport in the early 1930's, and he has recently provided a vigorous assertion of its continuing validity. (Allport, 1966)

Psychologists recognize and measure many traits of personality. Some traits are more general in nature and more pervasive in influence on human activities than others. Some traits are definitely more relevant to the educational enterprise than others, either because they set the conditions for what a student can accomplish in a given subject, or because they define the patterns of learned behaviors which are the objectives of courses of instruction. Some traits can be measured by paper-and-pencil tests and questionnaires, others cannot. The traits represented in the original TALENT variables were selected for their relevance to the study of education and its long-range consequences, and for their paper-and-pencil measureability. Project TALENT did not measure all the traits of the adolescent personality known to psychologists, but it did come much closer to measuring a complete set of educationally relevant variables than any previous large-scale research has.

The many traits measured can be organized under two main headings, so that each trait is classified as either an ability or a motive. Abilities are maximum performance variables. They represent the best performances an individual can muster when confronted with various classes of tasks. In an ability test the subject is confronted with a problem or work requirement and is expected to make his best effort to solve the problem or to satisfy the requirement. A comparison of the speed and precision of his performance with those of other people determines the relative degree of his ability. Motives govern both direction of behavior and intensity, or level of effort. Where an ability conditions what a person can do, a motive conditions what he chooses to do. The relative strengths of various motives possessed by a person are inferred from his answers to questions about his habits, his preferences, his goals and values, and his fears and frustrations. His responses to questions which are indicators of the degree to which he possesses a particular motive are carefully compared to the responses given by other people in the process by which he is assigned a scale score for that trait.

Ability is the generic term for a domain of traits which can be further classified as general intelligence, knowledges, and aptitudes. General intelligence is a very pervasive trait that facilitates quickness and quality of responses to all cognitive tasks to some degree. Since all problems or jobs that require covert symbol manipulation for their solution or completion are cognitive tasks, this is a very broad and important set of tasks indeed. Cognition occurs whenever mental symbol processing mediates responsive behavior. Whenever people use the mental abstractions we call "concepts" they are cognizing. School study assignments almost always define cognitive tasks, so that general intelligence operates to condition almost every school learning activity.

The factor in this theory that qualifies as a general intelligence source trait has been named Verbal Knowledges. This factor is the principal explanatory concept for 25 different surface traits of specialized knowledges and for the surface trait of reading comprehension, but more importantly, it is positively correlated with every one of the 60 surface traits in the abilities domain to some extent. Clearly this

factor qualifies as a "general intelligence" or "g" factor as Spearman originally defined it. Spearman said in 1927 that g "consists in just that constituent--whatever it may be--which is common to all the abilities." He spoke at that time of the "indifference of the indicator," to emphasize that a measure of g can be extracted from any set of maximum performance items for which performances are mediated by symbol processing. The predominance of specific knowledges as primary indicators of our g factor (hence the name, Verbal Knowledges) reflects John Flanagan's wartime experience with military test programs, in which tests of special knowledges, called information tests, proved to be the most generally useful predictors of criterion performances. Other testing programs have returned similar results. The theoretical explanation of the value of special information items as predictors can be found in Robert Gagné's theory of a hierarchy of learning sets mediating criterion achievement. (See Gagné and Paradise, 1961.) Gagné holds that individual differences in rate of achievement are related to differences in amounts and kinds of available relevant knowledge. These knowledges are organized in a hierarchy of learning sets, in which subordinate sets mediate transfer to higher level sets. Incidentally, he hypothesizes lower-level learning sets that are quite similar in nature to what we will define as aptitudes. He makes acquisition of required specific knowledges dependent on the mediation of appropriate aptitudes, in part, and in turn higher level achievements (what we would call higher mental processes) depend primarily on transfer from immediately subordinate specific knowledges. Gagné's paradigm is essentially this:

Complex Abilities
↑
Basal Knowledges
↑
Differential Aptitudes

Gagné's theory suggests that there is a particular bundle of special knowledges that must be assembled to permit mastery of a particular complex ability. Our footnote to this is that a pervasive source trait of general intelligence collaborates with a special set of lower level aptitudes in facilitating the acquisition of any special set of basal knowledges.

A knowledge is a performance trait that enables the subject to reproduce associations or to complete gestalts from a broad class of cognitive holdings. A knowledge trait is an ability to generate and apply information in a subject-matter area. Knowledges may depend more on specific learning opportunities and less on innate characteristics of the central nervous, afferent, and efferent systems than do aptitudes. However, all classes of abilities must be thought of as compounded from interactions of genetic and environmental determinants. Two important knowledge factors, uncorrelated with Verbal Knowledges and uncorrelated with each other, appear in our theory: English Language and Mathematics. English Language is a language mechanics ability, the best indicators of which are tests of spelling, capitalization, punctuation, usage, and expression. Mathematics is an advanced mathematics and physics ability in which arithmetic computation and arithmetic reasoning do not figure. Thus we have three factors--Verbal Knowledges, English Language, and Mathematics--that comprise a set of key educational achievement constructs in our theory. We assert that public education has the responsibility to bring these three factors to as high levels of development as possible in all students, and that any student's educational achievement is pretty much indicated by his profile on these three key source traits.

An aptitude is a performance trait that facilitates speed and precision of response to items from a specific, unique class of relatively simple tasks. Our theory locates three such classes of tasks in the TALENT abilities tests, and defines as a set of three differential aptitude factors Visual Reasoning, Perceptual Speed and Accuracy, and Memory, each of which has ample precedent in the literature. There are also five less important knowledge factors in the full solution for the abilities domain which are discussed in Chapter Four.

The typical performance traits, or motives, measured in the TALENT battery have been grouped into two clusters. The first of these is a personality modality which Henry Murray has aptly named "needs." A need is a response set which impels a person toward or away from a class of environmental circumstances or social interactions which is either gratifying or punishing for him. Needs represent the person's fundamental

goals and values in living, often uncognized by him, and the deeply seated anxieties which plague him. In the degrees to which students accepted the various items among the 150 behavioral adjectives of the Student Activities Index as applying to themselves there is evidence regarding the relative strength of a general needs factor created by our theory, named Conformity Needs. This has been interpreted as a measure of the extent to which the adolescent subscribes to the middle-class mores of our society. We see it as corresponding to what Allen Edwards has described as the factor of Social Desirability, which he finds to be the main factor determining MMPI responses. (Edwards, 1964) We expect that a fairly high standing on this trait is prerequisite for success in many vocational undertakings in our society.

From a set of scales based on biographical items, with some contributions from the adjectival scales, the theory derives six other needs factors, titled Scholasticism, Activity Level, Leadership, Impulsion, Sociability, and Introspection. The most important of these to the educational enterprise would seem to be Scholasticism, which is interpreted as a measure of the need students have to improve their minds *per se*. Our schools and our society seem to place great value on this motivation for capitalization on academic opportunities.

The second cluster of traits in the domain of motives is widely recognized as the modality of interests. An <u>interest</u> is a highly focussed, specialized need for a specific, unique class of activities. Two types of interests are vocational interests directed to specific occupations and work activities, and avocational interests directed toward activities outside the world of work. In the TALENT Interest Inventory the student was confronted with a list of 205 occupational titles and names of activities and was required to state his degree of liking for each. From 17 surface traits based on these responses four interest factors emerged. They have been named Business Interests, Outdoors and Shop Interests, Cultural Interests, and Science Interests. Thus we have 11 uncorrelated factors in our structure for the motives domain.

The II orthogonal factors in the abilities domain are naturally correlated with the orthogonal factors in the motives domain, since what a person chooses to do stands in some functional relation to what he is able to do. Chapter Six reports the canonical correlation analysis of the structure of relationships between the constructs of ability and the constructs of motive adopted for this theory.

At first glance the factor structures may seem to be too simple, especially on the abilities side, where only six important factors have been named. Actually, we are pleased with the simplicity of the solutions, because we hope to teach these rubrics to educators as a working theory of adolescent personality. We even aspire to teach the rubrics to students and their parents in many cases. Also, it should be recognized that we started with a suitably complex collection of surface traits (60 abilities and 38 motives), and the simplicity of the reduced rank models for the data reflects the actual structure of the correlations within each domain, not a subjective decision. There is good precedent in the literature for our six key abilities factors. Thurstone settled for five Primary Mental Abilities, and they are correlated. More interesting is the following statement from Cyril Burt (1949).

> Five factors--all of them of special improtance in educational work, the verbal, the arithmetical, the spatial, the memory, and the speed factors--have been independently corroborated by more than a dozen investigators.

We think the six key abilities we have located represent a state-of-the-art set of factor measures for their domain, and we are immodest enough to claim that the II motives represent a step ahead in the provision of factor measures in their domain for educational psychology.

An important feature in the structure for each domain is the organization provided for the factors. In the abilities domain the organization is hierarchical at one level, a pattern urged by Vernon (1950) and Humphreys (1962). First we have a general intelligence factor, which Vernon and others in the English school have always held to be necessary.

> A general intelligence factor seems unavoidable since substantial positive intercorrelations are found when any cognitive tests are applied to a fairly representative population. (Vernon, 1965)

After removal of g, Vernon finds that tests tend to fall into two main groups, the first being a verbal-numerical-educational group (our Enlish Language and Mathematics factors), and the second a practical-mechanical-spatial-physical group (our Visual Reasoning, Perceptual Speed and Accuracy, and Memory factors). We do not pretend that our factors correspond exactly to those Vernon creates in these two clusters, the v:ed group and the k:m group, but we certainly have a hierarchy organized as his is. He defends such a hierarchy at one level very nicely.

> From the point of view of the practical tester, the hierarchical model seems more logical since, in making educational or vocational decisions, he can cover most of the ground just by applying g or g + v tests, and then supplement by spatial-mechanical, clerical, number, or other group-factor tests where relevant. In other words, measures of factors which are higher in the hierarchy generally have better external validity, or more generalizability...to capacities of everyday life; whereas many of the published primary factors seem to be so narrow, so specific to the particular test material, as to have no practical use. (Vernon, 1965)

Within the motives domain the pattern is not hierarchical, but there is a clear pattern. What we see is three distinct clusters of surface traits defining three distinct clusters of factors, and almost no overlap between the three clusters of original measures. The pattern looks like this:

Basis for Surface Scales	Factors
adjectival self-concepts →	Conformity Needs
autobiographical activities →	Scholasticism Activity Level
inventoried interests →	Business Outdoors and Shop Cultural Science Sex (control)

We hope that this measurement theory of adolescence is pleasing in its forms and its details. Nevertheless, the acid test of a scientific theory is whether it generates important research. The author is presently collaborating with William Cooley in a program of predictive validity studies using these factors as predictors against criterion variables derived from the Project TALENT follow-up studies. The report of these prediction studies will provide a sequel to this monograph within a year, and should prove the pudding. As foreshadowing, and to justify the tone of optimism in the last statement, it can be reported that the best vocational development criterion from the one-year follow-up studies has already been predicted from the abilities factors with the same degree of precision achieved in predicting from the full set of surface traits, and the factor-criterion relationships have a clean and convincing pattern that the surface traits-criterion relationships lack. For the same criterion, a similarly encouraging comparison of prediction from the motives factors with prediction from the motives surface traits has been developed. Also, Lyle Schoenfeldt is preparing a program of research on the Project TALENT twin pairs that have been typed for zygosity that will test a number of hypotheses about relative genetic determination of factors that have been stated later in this monograph. Finally, several data bank customers doing research on issues they have defined are already using the factors.

Our greatest hope for these factor rubrics is that they will be tested as a provisional solution to the problem of a language for a computer measurement system (CMS) in secondary schools. Cooley proposed

such a system as an aid to school guidance in 1964, and Cooley and Lohnes elaborated on the notion in the last chapter of the Project TALENT One-year Follow-up Studies report (Flanagan et al., 1966, Chapter Eleven). They posited that a CMS would make possible major improvements in the management of (1) the student cumulative record, (2) the student progress report, (3) the projection of educational and vocational potentials of students, (4) the periodic monitoring of individual learning prescriptions, (5) the appraisal of educational productivity of curriculum and staff, and (6) the provision of several kinds of continuation services to alumni. Such a CMS requires a reasonably simple, yet comprehensive and valid theory of adolescent traits, employing language that can be widely assimilated, a feasible set of tests and instruments for operationalizing the constructs of the theory, and a large reservoir of crucial predictive validities of the traits, derived from a continuing program of follow-up research on probability samples. There should be an enormous advantage for the present theory in the circumstance that all its trait and factor constructs are already in use in educational psychology, and some of them are already part of the ordinary language of education. Parallel forms of the TALENT tests and inventories could be produced by the test publishing industry, and batteries assembled from existing commercial tests could be scored for the factors of this theory. Project TALENT will continue to build the knowledge of predictive validities that is necessary, and will concern itself with the design and testing of CMS-generated counseling documents that can be incorporated in the guidance program. The full development in schools of a model CMS is probably best seen as a task for a Research and Development Center.

One psychologist has recently faced the question of whether we are doing too much testing in our schools, and has decided that we are not. We would like to borrow his eloquence in closing our argument.

> There can be no greater injustice to any individual than to allow major decisions concerning his education, employment, or treatment to be based on less than the maximum amount of the best possible information concerning him. (Schofield, 1966, p. 125)

Chapter Two

METHODS OF THE RESEARCH

I. INTRODUCTION

Our commitment to uncorrelated factors of total test variance represents a quest for maximum parsimony and accessibility. Orthogonal factors have the scientific virtue of greatest simplicity and the pragmatic virtue of direct computability from test scores. Fortunately, orthogonal factor solutions for total test variance have maximum mathematical and statistical virtues of elegance and tractability also. This chapter presents mathematical and statistical specifications and rationale for the research methods employed in these studies of Project TALENT data. It is a necessary part of the report, but the disinterested reader may pass immediately to the next chapter.

II. COMPONENTS OF A VECTOR RANDOM VARIABLE AND THEIR ESTIMATORS

The statistical way to say that the total test variance is to be factored is to specify that the analysis is to proceed on the expected values of the z-score cross products of tests. Let ζ be a vector random variable with m elements. (All vectors are column vectors unless they are primed. Thus z' is a row vector which is the transpose of z.) The m elements of ζ are the coordinates of a random point from the theoretic population, which is an ellipsoidal, or multivariate normal, swarm of points in m-dimensional space. Correspondingly, the m elements of z are standard scores on m tests for a random subject in a random sample from the population. Then

$$P = E(\zeta\zeta')$$

expresses that the population matrix of intercorrelations among the elements of the vector random variable, P (rho), is defined as the expected value of the matrix of crossproducts of standard scores. (Readers desiring a review of the algebra of expectations should see

W. L. Hays, 1963, pp. 667-671; for theorems on expectations of random vectors and random matrices see T. W. Anderson, 1958, pp. 14-39.) Note that $\zeta\zeta'$ is a column vector times a row vector yielding a matrix.

Of course, P is a theoretical parameter which will never be known to us. It is the researcher's game to get a statistical estimator of P from sample data. Let z_i be the m element vector variable that represents the m standardized scores observed on the ith subject. Let N represent the sample size, so that i = 1, 2, ..., N. The estimator of P is the sample correlation matrix, R, where

$$R = \frac{1}{N} \sum_{i=1}^{N} z_i z_i' \quad .$$

If we let j and k be subscripts for particular tests, so that j = 1, 2, ..., m and k = 1, 2, ..., m, the typical element of the matrix P is the population correlation coefficient ρ_{jk},

$$\rho_{jk} = E(\zeta_j \zeta_k) \quad .$$

The typical element of R is the statistical estimator of ρ_{jk},

$$r_{jk} = \frac{1}{N} \sum_{i=1}^{N} z_{ij} z_{ik} \quad ,$$

which expresses that the sample correlation coefficient is the average crossproduct of standard scores. Note that when j = k, the value of r_{jk} is unity so that R always has unities in its main diagonal,

$$r_{11} = r_{22} = \ldots = r_{mm} = 1 \quad .$$

These unities represent the total variances of the standardized test sample distributions,

$$s_{z_j}^{\ 2} = r_{jj} = \frac{1}{N} \sum_{i=1}^{N} z_{ij}^{\ 2} \quad .$$

It is the observed sample correlation matrix, R, that we have factor analyzed. All methods such as ours that analyze R may be called "components factor methods" to separate them from the large and popular class of methods called "communalities factor methods" that remove estimated error variance from R before factoring. Components factor methods yield factors that are computable as linear functions of observed test score vectors. Statisticians call a linear function y of a vector random variable ζ,

$$c' \zeta = y \quad ,$$

where c is a vector of coefficients, a <u>component</u> of ζ, thus the term "components factor analysis." The scalar algebra equivalent of the vector algebra expression for the linear function is

$$y = c_1 \zeta_1 + c_2 \zeta_2 + \ldots + c_m \zeta_m \quad .$$

III. PRINCIPAL COMPONENTS

Matrix theory suggests that the eigenstructure of R affords an elegant orthogonal factor solution. The eigenstructure of R consists of a diagonal matrix Λ and an orthonormal matrix V such that

$$R = V \Lambda V' \quad .$$

The diagonal matrix Λ (lambda) contains the eigenvalues of R,

$$\Lambda = \begin{bmatrix} \lambda_1 & 0 & 0 \ldots 0 \\ 0 & \lambda_2 & 0 \ldots 0 \\ \vdots & \vdots & \vdots \quad \vdots \\ 0 & 0 & 0 \quad \lambda_m \end{bmatrix}$$

The orthonormality of the matrix of column eigenvectors V implies that

$$V V' = V' V = I \quad ,$$

where I is an identity matrix, that is, a diagonal matrix with unities in the diagonal.

A very basic theorem of multivariate statistics states that the variance-covariance, or dispersion, matrix Δ_y of a set of linear components of a vector random variable can be computed by premultiplying the dispersion matrix of ζ, which is Δ_ζ, by the transpose of the transformation matrix and postmultiplying the product by the transformation matrix. A transformation matrix is composed of column vectors each of which contains the coefficients defining a linear component of the vector random variable. Letting C be such a transformation matrix, the theorem is

$$\Delta_y = C' \Delta_\zeta C \quad .$$

The sample space analogue for this theorem is

$$D_y = C' D_z C \quad .$$

However, it is very important to recognize that in the case of standardized variables distributed N(0,1), so that all the means are zero and all the variances are unity, the dispersion matrix is the correlation matrix. By definition

$$\Delta_\zeta = E\left[(\zeta - E(\zeta)) \ (\zeta - E(\zeta))'\right]$$

but when

$$E(\zeta) = 0 \quad \text{and} \quad E(\zeta_i^{\ 2}) = E(\zeta_j^{\ 2}) = 1 \quad ,$$

$$\Delta_\zeta = E(\zeta\zeta') = P \quad .$$

Correspondingly in the sample space, if $M_z = 0$ and $S_z^{\ 2} = I$, then $R = D_z$.

Looking at our expression for the eigenstructure of R,

$$R = V \Lambda V' \quad ,$$

if we postmultiply by V,

$$R V = V \Lambda V' V = V \Lambda I = V \Lambda \quad ,$$

then premultiply by V',

$$V' R V = V' V \Lambda = I\Lambda = \Lambda \quad ,$$

what results is

$$\Lambda = V' R V \quad .$$

Since V is a transformation matrix and R is a standardized dispersion, this is a special case of the general theorem and Λ is the dispersion matrix for the linear functions, or factors, y, of z, where

$$Y = V' Z \quad .$$

Note that Z is an m rows by N columns score matrix, or data matrix, containing the score vectors for all N subjects, while Y is an m by N principal components score matrix.

Since Λ is a diagonal matrix, all the covariances among the y variables are zero so the principal components are uncorrelated. Each diagonal element of Λ is the variance of the component of z defined by the corresponding column eigenvector of V. Thus

$$S_{y_i}^{\ 2} = \lambda_i = v_i' R v_i \quad .$$

By means of the differential calculus it can be shown that λ_i is the maximum value the variance of a component of z can have, subject to the restriction $v_1' v_1 = 1$. It can also be shown that λ_2 is a maximum, given λ_1, $v_1' v_1 = 1$, $v_2' v_2 = 1$, and $v_2' v_1 = 0$, and so on for the remaining eigenvalues. Each component has maximum variance out of all possible linear functions orthogonal to the ones preceding it. This is the remarkable property of the principal components. We have previously quoted T. L. Kelley's observations on this property, to the effect that it is a valuable property to have in factors, if there are no more pressing considerations. In Kelley's day there were no more pressing considerations, so he was inclined to accept the principal components as a research solution.

One other remarkable feature of principal components is that while the complete set of m components will exactly reproduce the correlation matrix R, and thus accounts for all the variance in the vector variable z, it is possible to retain in a research solution only the first n of the components, with confidence that these n factors extract more of the variance of z than any other set of n orthogonal factors would. This is of immense importance. If for reasons of parsimony we intend to reduce the number of variables in our research from m correlated variables z to $n < m$ uncorrelated derived variables y, the n derived variables that will retain as much of the variance of z as possible are the first n principal components.

IV. THEORY AND ERROR PARTITIONS OF R

The matrix $v_1 \lambda_1 v_1'$ defines that part of R which is accounted for or extracted by the first component. If a residual matrix $\hat{R}$ is defined as

$$\hat{R} = R - v_1 \lambda_1 v_1' = R - R_1 \quad ,$$

then $\hat{R}$ and R_1 represent an orthogonal partition of R. An important property of matrices in factor theory is rank. The rank of a matrix

is the number of nonzero eigenvalues it has. The rank of R is m, which is also its order (number of rows and columns). The rank of $\hat{R}$ is m-1, and the rank of R_1 is one, although the order of each is m. R is said to be of full rank, whereas $\hat{R}$ and R_1 are of reduced rank.

Now if $\hat{\hat{R}}$ is defined as

$$\hat{\hat{R}} = \hat{R} - v_2 \lambda_2 v_2' = \hat{R} - R_2 = R - R_1 - R_2 \quad ,$$

then the rank of $\hat{\hat{R}}$ is m-2, the rank of R_2 is one, and we have partitioned R into three orthogonal addends,

$$R = \hat{\hat{R}} + R_1 + R_2 \quad .$$

Let us define R_{res} as the residual after the extraction of n factors,

$$R_{res} = R - R_1 - R_2 - \ldots - R_n \quad .$$

The rank of R_{res} is now m-n. If we define $\tilde{R}$ as

$$\tilde{R} = R_1 + R_2 + \ldots + R_n \quad ,$$

then $\tilde{R}$ is of rank n, and is the part of R "explained," or accounted for, by n factors. We speak of $\tilde{R}$ as the theory matrix, because it is what the correlations among the elements of z would be if z were entirely explained by the n factors.

The principal components already have zero means, because of a basic theorem that states that if $E(\zeta) = 0$, then $E(C' \zeta) = E(y) = 0$. It is conventional and very convenient to standardize all factor score distributions, so that whenever we speak of a factor we imply zero mean and unit standard deviation. Since y_i has variance λ_i, the standardized

component may be obtained as

$$f_i = y_i \,/\, \sqrt{\lambda_i} \quad ,$$

or for all components

$$F = \Lambda^{-1/2}Y \quad .$$

If we now define the "explained" part of ζ as $\tilde{\zeta}$, where

$$\tilde{\zeta} = A\ f \quad ,$$

making the explained part of the random variable ζ a set of m linear functions of the n element vector factor variable f (so that A is an m by n coefficients matrix), then

$$\tilde{P} = E(\tilde{\zeta}\tilde{\zeta}') \quad ,$$

and the corresponding results in the sample space are

$$\tilde{Z} = A\ F$$

and

$$R = \frac{1}{N}\tilde{Z}\ \tilde{Z}' \quad .$$

Thus R has been partitioned into a theory part, $\tilde{R}$, and a residual or error part, R_{res}. Obviously, the closer the elements of R_{res} are to zero the better the fit of the theory and the happier the investigator, given than n seems to be the right number of factors for other reasons as well.

V. FACTOR PATTERN

The coefficients A in the definition

$$\tilde{Z} = A\ F$$

are extremely interesting. They are called factor loadings since they reveal the weight attached to each factor in the set of factors, F, in explaining each element of z. That is, a_{jk} is the loading of factor k on test j, and is the weight given to f_k in explaining z_j.

$$\tilde{z}_j = a_{j1}\ f_1 + a_{j2}\ f_2 + \ldots + a_{jn}\ f_n \quad .$$

Another interesting result is

$$\begin{aligned} \tilde{P} &= E(\tilde{\zeta}\tilde{\zeta}') \\ &= E[(A\ f)(A\ f)'] \\ &= E(A\ f\ f'\ A') \\ &= E(A\ I\ A') \\ &= A\ A' \quad . \end{aligned}$$

This result obtains because E(f f') = I, since the factors are uncorrelated with zero means and unit variances, and because the expected value of a product of constants, E(A A') is the product itself. The corresponding relationship in the sample space is

$$\tilde{R} = A\ A' \quad .$$

Thus we see that the theory matrix may be obtained from the factor loadings. For principal components the loadings are given by

$$A = V\ \Lambda^{1/2}$$

and this is true for only n factors (the reduced rank model) as well as for m factors (the full rank model). In the reduced rank model A has m rows (corresponding to the m tests in Z) and n columns, V has m rows and n columns, and Λ is reduced to an n-square diagonal matrix.

The greatest interest in any factor solution attaches to the correlations between the original variables, z, and the factors, f. The matrix of such test-factor correlations, R_{zf}, is called the <u>factor structure</u>. The element r_{jk} gives the correlation of the jth test with the kth factor. Assuming that the content of the original tests is well known, the correlations in the kth column of the structure help in interpretation, and perhaps in naming, of the kth factor. Also, the coefficients in the jth row give the best view of the factor composition of the jth test.

The derivation of $P_{\zeta f}$ is as follows:

$$
\begin{aligned}
P_{\zeta f} &= E[(\zeta - E(\zeta)) \quad (f - E(f))'] \\
& E(\zeta \; f') \\
&= E[\zeta \; (\Lambda^{-1/2} \; y)'] \\
&= E(\zeta \; y' \; \Lambda^{-1/2}) \\
&= E[\zeta \; (V' \; \zeta)' \quad \Lambda^{-1/2}] \\
&= E(\zeta\zeta' \; V \; \Lambda^{-1/2}] \\
&= P \; V \; \Lambda^{-1/2}
\end{aligned}
$$

and since $P \; V = V \; \Lambda$

$$
\begin{aligned}
P_{\zeta} &= V \; \Lambda \; \Lambda^{-1/2} \\
&= V \; \Lambda^{1/2} \\
&= A
\end{aligned}
$$

Similarly, in the sample space

$$R_{zf} = A \quad .$$

For principal components, the factor loadings matrix is also the factor structure matrix! As a matter of fact, the same result holds for any orthogonal factor solution, although the general proof is different. Usually we will speak of A or R_{zf} as the <u>factor pattern.</u>

VI. GENERALIZED VARIANCE

When applied to a matrix of intercorrelations among maximum performance measures the principal components method inevitably produces a substantial g factor as the first component, followed by a set of bipolar factors. This happens because the intercorrelations among ability tests are all positive, although some of them may be quite low. The higher these positive correlations run in a data matrix the larger the portion of the generalized variance extracted by the g factor.

The notion of generalized variance needs explication. In factor theory it is useful to take the number of elements in z, namely m, as the generalized variance of the system of observations. This number is also the sum of the elements on the main diagonal of R,

$$r_{11} + r_{22} + \ldots + r_{mm} = m \quad .$$

The sum of the main diagonal of a square matrix is called the trace. An interesting outcome of eigenstructure theory is that if RV = VΛ, then

$$\text{trace}\ (\Lambda) = \text{trace}\ (R) \quad .$$

In the case of components analysis, this means that the sum of the variances extracted by m principal components is m, the generalized variance of R. This is a technical specification of a complete factoring of R, similar to the specification that $R_{res} = 0$ (the null matrix

containing only zeros). When n largest components are selected as the basis for a solution, the ratio

$$\left(\sum_{k=1}^{n} \lambda_k \right) / m$$

gives the proportion of the total generalized variance that is accounted for by n factors.

The problem of choosing a value for n in a particular research is a thorny one. The main point is that the research report should offer some rationale for the choice of n that has been made, and should show the distribution of residuals, R_{res}, for n factors. One rule of thumb which is helpful is the observation that when $\lambda_k < 1$ the factor involved extracts less variance from the system of observations than the typical variance of any single observational scale, since $S_{z_j}^{\ 2} = 1$. Such a factor does not promise to be very useful in a research program. However, there is greater hazard in under-factoring than in over-factoring, since unwanted factors can always be ignored in later parts of a research program, but useful factors that are not retained may be lost for good. Our practice is to make n large enough to include one or two components that have negligible loadings on all but one test, indicating that we have extracted all the common factors.

VII. COMMUNALITIES

By common factors we mean simply factors that are significantly correlated with two or more of the original variables. Such a factor helps to explain the intercorrelations among the variables, whereas a specific factor that is significantly correlated with only one variable may help to explain the variance of that variable but cannot help to explain its covariances with other variables in the system of observations. In a research like ours which is seeking explanatory concepts for observed interrelationships among behavior traits, interest centers on common factors.

How much of the variance in a given test, z_j, is accounted for by the n factors of a solution? The answer is defined as the communality, h_j^2, of test j, and is given by

$$h_j^2 = a_{j1}^2 + a_{j2}^2 + \ldots + a_{jn}^2 \quad .$$

That is, the square of the correlation of test j with factor k gives the part of the variance of the test accounted for by that factor, and the sum of these squares for n factors is the communality, or explained variance, for the test.

How large should a communality be? To answer this requires an estimate of the amount of variance a test has in common with other tests in the system. The most straightforward approach to such an estimate is to compute the squared multiple correlation of the test with a best linear function of the other m-1 tests. These squared multiple correlations are lower bounds for the theoretical communalities of the tests. They may be thought of as redundancy measures for the tests. It seems to be good practice to require that the achieved communalities equal or exceed these lower bounds, and to choose n so that for every test, j = 1, 2, ..., m,

$$h_j^2 \geqq R_{M_j}^2 \quad .$$

Given the inverse of R, which is a matrix denoted R^{-1} such that

$$R\,R^{-1} = R^{-1}\,R = I \quad ,$$

the required squared multiple correlations are directly obtainable. Let r^{jj} be the jth diagonal element of R^{-1}. Then

$$R_{M_j}^2 = 1 - \frac{1}{r^{jj}} \quad .$$

There are several ways to compute R^{-1}, but if a complete eigensolution for R has been computed, as we are assuming it has, then

$$R^{-1} = V \Lambda^{-1} V'$$

where $\lambda^{jj} = 1 / \lambda_{jj}$, so that the inverse follows very simply from the eigenstructure. (Parenthetically, it can be seen that R must be of full rank if it is to have an inverse, for if its rank is less than its order, then for at least one eigenvalue the computation of λ^{jj} involves trying to divide by zero.)

VIII. ANALYTIC ROTATION

Since Thurstone laid down the principles of simple structure, factor analysts have been interested in schemes for improving on the solution offered by n principal components by rotating the components to positions in which the factor pattern comes closer to Thurstone's notions. The idea of analytic rotation schemes is to have the computer further transform the principal components in ways which preserve the elegance, tractability, and utility of the set of components, while garnering the additional virtue of a closer approximation to simple structure. It is very important to recognize that all the value of a set of n components as a set is preserved under analytic rotation. That is, $\tilde{R}$, R_{res}, and the communalities are undisturbed. What does change is the specifications for the separate factors given by the elements of A. The row sums of squares for A do not change, but the elements of each row are modified toward simple structure. This means simply that an effort is made to have all a_{jk} approach either zero or unity, on the grounds that very high and very low factor loadings are easily interpreted, whereas middle-sized loadings give trouble. As Henry Kaiser, who invented the varimax rotation scheme employed in this research says, "Since a factor is a vector of correlation coefficients, the most interpretable factor is one based upon correlation coefficients which are maximally interpretable." (Kaiser, 1958)

There are two competing analytic rotation schemes we had to choose between. The first, historically, is the quartimax method, which maximizes the variance of the squared loadings,

$$\sum_{j=1}^{m} \sum_{k=1}^{n} a_{jk}^4 \Big| \max \quad .$$

Since each row sum of squares must be left undisturbed, what the quartimax method does is to simplify each row, or test, by maximizing within-row variances of squared loadings. Kaiser's alternative, the varimax method, sets out to simplify columns, or factors, in A, by maximizing the variance of the squared coefficients of correlation of the common parts of the tests with each factor. His criterion is

$$\sum_{k=1}^{n} \{[m \sum_{j=1}^{m} (a_{jk}^2 / h_j^2)^2 - \Big(\sum_{j=1}^{m} (a_{jk}^2 / h_j^2)\Big)^2] / m^2\}$$

which is maximized by the iterative application of a set of trigonometric functions. Apparently a great many researchers have had the kind of satisfaction with varimaxed factor patterns for their data that the author reports for TALENT data, judging by the popularity of the method. In our case, we had quartimax rotations to compare with the varimax results, but found the latter to be cleaner and more useful in every case. In fact, we have been somewhat astonished with the "insights" the varimax method of rotation has sponsored in our research.

IX. FACTOR SCORE COEFFICIENTS

An important difference in purpose between the factor analyses of this research and most published factor analytic studies has been the intention in this research to convert very large files of observational scale scores to factor scores. Usually factor analyses have been done for heuristic purposes only, and the factor pattern has been the final computational product. Many researchers have employed

factoring procedures from among the communalities factor analyses for which they would have been unable to score the resulting factors. The virtue of a straightforward scoring scheme for the factors has been such a prime requirement in the selection of methods for this research that we have given it a name: accessibility. We have taken this requirement to mean that the factors must be direct linear components of the observation vectors. This not only ruled out the use of some communalities factor analyses, such as the Kaiser-Caffrey Alpha analysis, but also ruled out use of an otherwise attractive style of components analysis known as image analysis, in which the covariances of the regressed images of the tests, each in the space of all the others, are factored. There is no published scoring scheme for image factors, and the author could not see the possibility of a straightforward solution.

We have already seen that the scoring of principal components requires only a rescaling of the eigenvectors to standardize the factor scores,

$$F = \Lambda^{-1/2} Y = \Lambda^{-1/2} V' Z = C' Z$$

where the factor score coefficients are defined as

$$C = V \Lambda^{-1/2}$$

This is a special case, however, and has no application to the general orthogonal factors case, which prevails after varimax rotation of n components. The solution for factor score coefficients in the general case depends on simple multiple regression of the factors, one at a time, on the space of the original variables.

If each column of the factor pattern, A, is construed as a set of criterion (the factor) - predictor (the original tests) correlations, premultiplication of the column by the inverse of the intercorrelation matrix for predictors yields a vector of beta weights for the multiple regression of that factor on the tests. Letting the vector a_k be the kth column of A,

$$\beta_k = R^{-1} a_k \quad .$$

If we assemble the n column vectors β_k in the matrix C of score coefficients, then

$$C = R^{-1} A$$

and

$$F = C' Z \quad .$$

The matrix C' provides a transformation of standard scores on the observation variables. Incidentally, but not trivially, if Z is N(0, P) then F is certainly N(0, I), and even if Z is not multivariate normally distributed the central limit theorem suggests that F will tend toward N(0, I). Also, if m is substantially larger than n, there should be important gains in score reliability to offset the surrender of profile detail.

X. SEX AND GRADE EFFECTS IN THE DATA

The purpose of this research has been to produce a measurement theory for middle adolescence. An unavoidable complication is that there are two distinct types of American adolescents, namely boys and girls. Another reality is that the developmental period under scrutiny spans four grades of high school and more than four years of chronological age. The briefest look at the statistics for sexes and grades in *The American High School Student* (Flanagan et al., 1964) indicates the existence of highly significant sex and grade differences in the Project TALENT variables. For pragmatic reasons the author wanted to avoid the adoption of separate factor solutions for each sex-grade interaction group, or even for each sex or for each grade. The great similarities in the factor solutions reported for sex-grade groups encouraged him in the quest for a single, common solution. Nevertheless, the real sex and grade effects on many of the scales could not be ignored. Somehow they had to be accounted for. It would have been

very misleading to have factored a total sample correlation matrix with no regard for the excessive heterogeneity introduced by mixing sexes and grades.

The parsimonious hypothesis was to attribute the sex and grade effects in the data solely to constant values of group membership. By this hypothesis all members of a group receive a constant increment (or decrement) on each scale as an adjustment to the grand mean for that scale, as the sole recognition of the influence of group membership on performances on that scale. Having decided to adopt this hypothesis, the author had to define the groups for which constant membership increments or decrements were to be computed.

One possibility was to have eight sex-grade interaction groups. An initial decision was made not to sample the two middle grades, ten and eleven, but instead to sample only grades nine and twelve to provide the desired grades-effect contrasts. This decision was based primarily on economic considerations, but it turned out to be a crucial one in enabling the choice of methods that emerged. Given, then, large random samples from four data files,

Ninth grade Males	9M
Ninth grade Females	9F
Twelfth grade Males	12M
Twelfth grade Females	12F

a possibility was to compute a membership value for each scale for each of the four subsamples. This strategy would incorporate allowances for possibly significant sex-grade interaction effects, in the analysis of variance sense, although it might not decompose the adjustment constant for a cell into a sex part, a grade part, and an interaction part. We call this alternative the full linear model strategy. Another possibility was to compute separate adjustment constants for sex and grade memberships (each a dichotomous contrast), and to ignore possibly real sex-grade interaction effects. This was patently unrealistic for a few variables (e.g., mathematics, in which boys improved from ninth to twelfth grades while girls showed a declining trend), but had an attractive analytic quality overall, which is discussed

below under the name of the point biserial correlation method. With the usual misgivings of a researcher faced with a choice among promising methods, we chose this latter strategy. We did compute the full linear model on our data as well, and have reported the considerable agreement between the results of the two strategies.

XI. THE FULL LINEAR MODEL

The full linear model is the multivariate extension of the familiar analysis of variance, and in fact is now widely referred to as the MANOVA model, for "multivariate analysis of variance." As we will treat it, manova is a Type I, fixed effects model. In our application the fixed effects are sex and grade, and each has two levels. It is the criterion variable, which in analysis of variance is assumed to be normally distributed, that has become multivariate in manova. We assume for a criterion a vector random variable with a multivariate normal distribution. For ease of presentation we are also going to assume that this vector variable has been standardized for total sample. Thus we call our criterion ζ (z in the sample space), and both ζ and z will have a null vector for the grand centroid (vector of grand means), unit standard deviations for total sample, and correlations in the total sample dispersion matrices, P and R. There is no loss of generality involved in enforcing these conventions.

Where the basic theorem of manova partitions a total sum of squares into additive parts, the manova model partitions a total sums of squares and crossproducts matrix into orthogonal and additive part matrices. One part becomes the hypothesis, effects, or among-groups matrix, and the other part becomes the residual, error, or within-groups matrix. We will use the symbol B for the sample space hypothesis sums of squares and crossproducts matrix, and W for the sample space error s.s.c.p. matrix. Letting T be the sample space s.s.c.p. around the grand centroid,

$$T = B + W \quad .$$

When there are two or more main effects, the possibility exists of further partitioning B into orthogonal, additive matrices for each main effect and each possible interaction effect. In our case, we might seek the full partition

$$T + B_{Sex} + B_{Grade} + B_{SxG} + W$$

where

$$B = B_{Sex} + B_{Grade} + B_{SxG} \quad .$$

Whether or not we partition B fully, our primary interest is in W, because we want to convert it to a pooled-within-groups correlation matrix, and factor that matrix. What we seek are factors of the error correlation matrix. That is the matrix that has had the disturbing effects of constants for sex-grade cell memberships removed.

The full linear model analyzes the vector random variable by the equation

$$\zeta_k = \beta_k + \varepsilon$$

in which ζ_k, the total observation, random from the kth cell, and ε, the error component, are vector random variables, but β_k is a vector of constants for membership in the kth interaction cell. For each basic cell of the design there is a different vector of constants, of course. Translated into sample terms, the equation becomes

$$\begin{aligned} z_{ki} &= b_k + e_i \\ &= \bar{z}_k + (z_{ki} - \bar{z}_k) \quad , \end{aligned}$$

in which the observation vector for the ith subject in the kth cell is partitioned into the hypothesis value $\bar{z}_k$, which is the centroid for the kth cell, and the error value, which is a residual.

In the sex x grade factorial design the vector random variable may be analyzed by

$$\zeta_{jk} = \beta_{S_j} + \beta_{G_k} + \beta_{SxG_{jk}} + \varepsilon \quad ,$$

for which the sample space analogue is

$$z_{jki} = b_{S_j} + b_{G_k} + b_{SxG_{jk}} + e_i$$

or

$$z_{jki} = \bar{z}_{S_j} + \bar{z}_{G_k} + (\bar{z}_{SxG_{jk}} - \bar{z}_{S_j} - \bar{z}_{G_k}) + e_i \quad .$$

Since $\bar{z}_{SxG_{jk}}$ is a sex-grade interaction cell mean vector, this simplifies to exactly what we had above. The residual or error is the same whether or not we take the trouble to partition B into its factorial parts. As our research effort with the full linear model did not separate the between cells effect into separate sex, grade, and interaction effects, we will continue the algebra on the simpler scheme that denotes by $\bar{z}_k$, k = 1, 2, 3, 4, the centroids for the four interaction cells, namely 9M, 9F, 12M, and 12F. We wish to show how the error correlation matrix was computed.

Note that for a sample member i from the kth cell, the error vector is

$$e_i = z_{ki} - \bar{z}_k \quad .$$

If there are N_k sample members for the kth cell, the within cell sum of squares and crossproducts of errors is

$$W_k = \sum_{i=1}^{N_k} e_i e_i'$$

and the pooled within s.s.c.p. matrix is

$$W = \sum_{k=1}^{4} W_k \quad .$$

Multiplying W by 1/(N-4) produces the pooled within groups dispersion estimate, $\hat{D}$, the p, qth element of which is

$$\hat{d}_{pq} = \frac{\sum_{k=1}^{4} \{ \sum_{i=1}^{N_k} (z_{kip} - \bar{z}_{kp})(z_{kiq} - \bar{z}_{kq}) \}}{\sum_{k=1}^{4} (N_k - 1)}$$

This dispersion estimate is readily converted to the error correlation matrix $\hat{R}$, with the p, qth element

$$\hat{r}_{pq} = \frac{\hat{d}_{pq}}{\sqrt{\hat{d}_{pp} \quad \hat{d}_{pq}}} \quad .$$

Note that we have arrived at the desired correlation estimate after adjustment for constant sex-grade cell effects without requiring a balanced design. This approach allows a varying N_k, whereas the full manova model, with its illuminating partition of B into B_{Sex}, B_{Grade}, and $B_{interaction}$, would have required equal cell sizes, N_k = N/4. Our four data files are of different sizes, and we chose to work with 10 per cent random samples of the files (our samples were about 4,000 subjects per cell).

What does the error correlation matrix represent? The basic assumption of the linear model is that all the populations have the same dispersion, and therefore the same correlation matrix. The assumption in our case is that

$$P_{9M} = P_{9F} = P_{12M} = P_{12F} = P \quad .$$

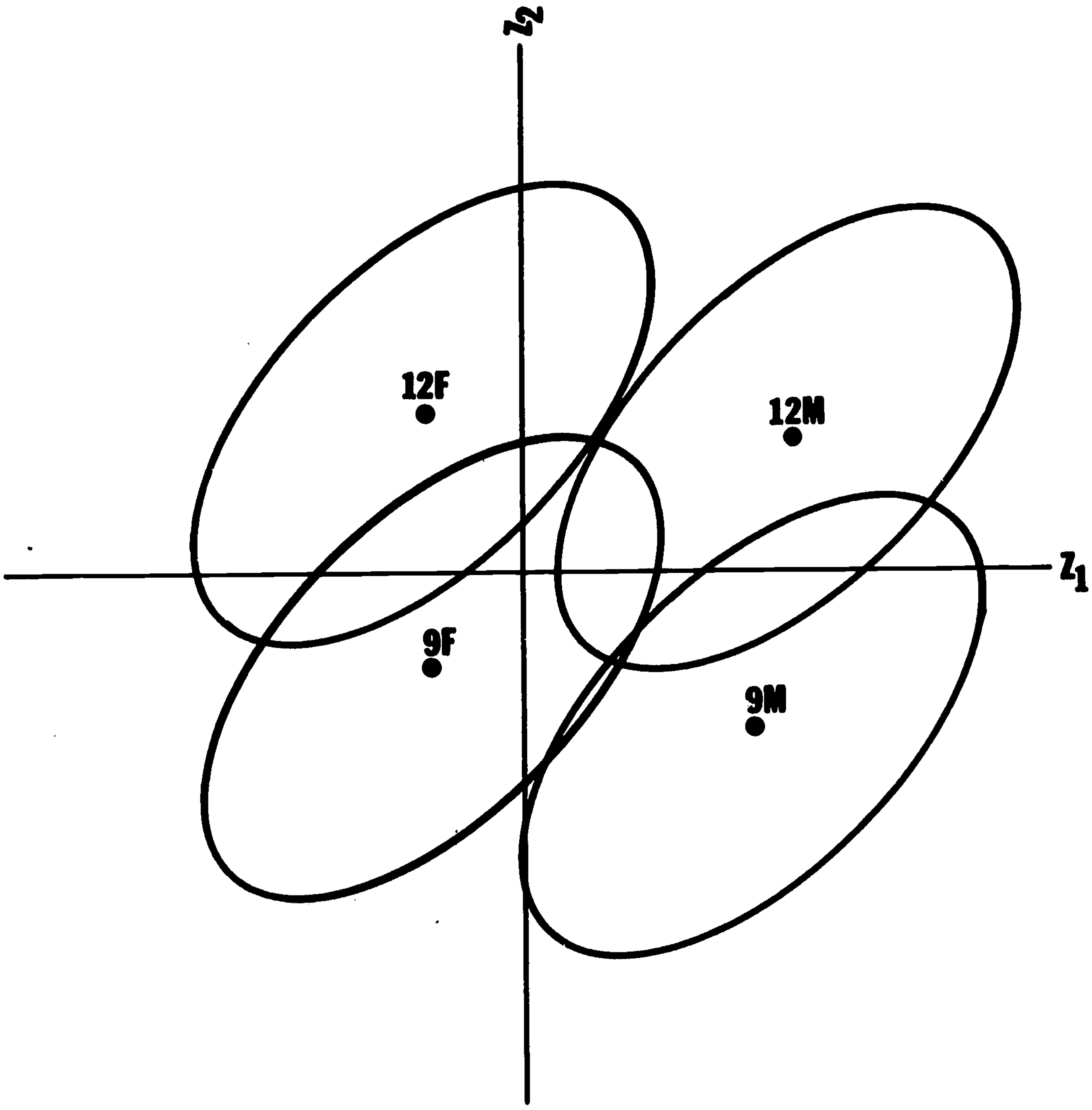
The error correlation matrix is an estimator of P,

$$\hat{R} \cong P \quad .$$

Assuming m = 2 for diagrammatic purposes, Figure I shows the kind of situation that is assumed to exist. The four populations have the same bivariate normal dispersion, but they are located in four different places in the measurement space. The parameters of the linear model are location parameters. The correlation between trait p and trait q does not depend on these location parameters, that is, ρ_{pq} is the same for all four groups.

Factoring $\hat{R}$ seems at first glance to be the obvious procedure to operationalize, but reflection reveals some drawbacks. First, each subject must be deviated from his own sex-grade cell centroid before factor scores can be computed for him. The rub in this is that on every factor the four cells will have identical, zero sample means. It might be useful to have the sexes and grades "equalized" in this way, but it really would not be very acceptable in other than artificial, research situations. The purpose of the program is to produce variables which will be acceptable to educators generally as dimensions of adolescent personality. Surely educators will demand factors on which sex and grade differences appear naturally, as mean differences. Second, the factor analysis of $\hat{R}$ will not display the relative strengths of the relations of either the original variables or of the factors to the design variables of sex and grade. The next section undertakes to defend a model that meets both these objections, and that is analogous to a restricted linear model.

Figure I: Four populations differentiated by location parameters but have equal dispersions



XII. POINT BISERIAL CORRELATION METHOD

To meet the needs of this research program the author tailored a unique method of accomodating systematic sex and grade differences in the total sample. The method capitalizes on the dichotomous contrasts for sex and grade, and on the very large sample sizes in the cells. These sample sizes are

Design Cell	Abilities Sample	Motives Sample
9th Male	4758	4570
9th Female	4632	4536
12th Male	3602	3525
12th Female	3793	3736
Total	16785	16367

Point biserial correlation coefficients were computed between each of the 60 ability tests and sex. These coefficients, which are product moment correlation coefficients, were added to the total sample R matrix to provide row 61 and column 61. Then point biserials were computed with the 60 abilities and grade and added to total R to provide row 62 and column 62. The missing elements $r_{61,62}$ and $r_{62,61}$ were added as the computed ϕ (phi) coefficient between sex and grade. This is also a product moment correlation. In this sample space for abilities traits the computed value of ϕ is .000, and this is also the computed value for the motives traits sample space. In the same manner, point biserial correlations of sex and grade with the 38 motives measures were computed and added to total sample R as rows and columns 39 and 40.

Point biserial r, or r_p, is a function of group means, total sample standard deviation, and group sample sizes. Walker and Lev (1953, pp. 261-274) is an excellent reference on both r_p and ϕ. The definition formula for point biserial correlation is

$$r_p = \frac{\overline{X}_1 - \overline{X}_2}{S_x} \sqrt{\frac{N_1 \quad N_2}{N(N-1)}}$$

where $N = N_1+N_2$ and $S_x = \sqrt{\sum_{i=1}^{N} (X_i - \overline{X})^2 / (N - 1)}$.

Assuming large enough samples so that N-1 may be treated as N, a useful version of the formula is

$$r_p = \frac{\overline{X}_1 - \overline{X}}{S_x}\sqrt{\frac{N_1}{N_2}} = \frac{\overline{X} - \overline{X}_2}{S_x}\sqrt{\frac{N_2}{N_1}} .$$

The formula for ϕ is

$$\phi_{Sex,\ Grade} = \frac{N_{12M} \quad N_{9F} \quad - \quad N_{9M} \quad N_{12F}}{\sqrt{(N_{9M}+N_{12M})(N_{9F}+N_{12F})(N_{9M}+N_{9F})(N_{12M}+N_{12F})}} .$$

The augmented total sample correlation matrix, R, has the advantage that its last two rows (or columns) explicitly display the relationships of the measurement variables to the moderator variables of sex and grade. Since they are pure numbers on the same scale as ordinary correlation coefficients, the point biserial coefficients are much more readily interpreted than are the raw score mean differences for sexes or for grades. Note that since the ratio N_1/N_2 for sexes is practically unity in our samples, the point biserial with sex is essentially a standard score transformation of a linear contrast. For a balanced design (exactly equal cell sample sizes) executed on a standardized variable, the point biserial correlation of a dichotomous design variable with a continuous criterion variable is precisely an estimate of a parameter of the linear model,

$$r_p = \bar{z}_1 = b_1 \quad .$$

How can this augmented total sample R matrix be factored properly? The correlations among the traits are still artificially inflated by the influence of correlated subsample means. It is necessary to remove that influence initially. The method chosen is to pass a group factor directly through the sex variable, factoring out all variance in the traits that is associated with the moderator variable of sex. Then a second group factor is passed directly through grade, getting all the variance in the trait residuals from sex that is associated with the moderator variable of grade. The residual variances and covariances in the measurement traits after extraction of these two arbitrary factors can then be factored for factors of the error covariance matrix by principal components method.

The method of extracting the arbitrary sex and grade factors is best described by Overall (1962), who also presents an elegant proof of the orthogonality of the arbitrary factors to each other and to any factors of the residual or error matrix. His paper is a classic in the factor analysis literature.

To pass a factor through sex we define an arbitrary factor vector $\tilde{h}_1$ that has zeros in every position except the position of the sex variable (element 61 for the abilities R; element 39 for the motives R), where it has unity. We then scale this arbitrary factor vector so that

$$h_1' R h_1 = 1 \quad .$$

This is accomplished by computing

$$h_1 = [1 / \sqrt{\tilde{h}_1' R \tilde{h}_1}] \tilde{h}_1 \quad .$$

The factor structure correlations for the first factor are

$$a_1 = R\, h_1 \quad .$$

This is a perfectly general method for defining an arbitrary factor on a vector variable with dispersion R. The arbitrary factor vector may be given any desired definition. In our special case, the vector of sex factor loadings a_1 turns out to be precisely the point biserials of the traits with sex, column 61 of abilities R or column 39 of motives R. The loading of 1.00 for the sex variable on the sex factor indicates that the communality for the sex variable, $a_{1,Sex}^{\;2}$, is unity, so that all the sex variance has been extracted.

This first factor is now extracted, or "exhausted," from R, leaving the first residual matrix, $\hat{R}$,

$$\hat{R} = R - R_1 = R - a_1\, a_1' \quad .$$

Note that the elements of the row and column of $\hat{R}$ for the sex variable will be zeros.

To pass the second factor through grade we define an arbitrary factor vector $\tilde{h}_2$ that is all zeros except for a one in the grade position (element 62 for abilities, or element 40 for motives). Again we transform to unit variance,

$$h_2'\, \hat{R}\, h_2 = 1$$

where

$$h_2 = [\, 1 \,/ \sqrt{\tilde{h}_2\, \hat{R}\, \tilde{h}_2}\ ]\, \tilde{h}_2 \quad .$$

The loadings for the grade factor are

$$a_2 = \hat{R}\, h_2 \quad .$$

Again, in our special case, the grade factor loadings a_2 turn out to be exactly the point biserials of the traits with grade (this is possible because $r_{S,G} = 0$ and no grade variance was removed by the sex factor), and the communality for grade goes to one, showing that all grade variance has been accounted for. The matrix is now exhausted of this second arbitrary factor,

$$\hat{\hat{R}} = \hat{R} - R_2 = \hat{R} - a_2\, a_2' = R - R_1 - R_2 \quad .$$

The residual matrix $\hat{\hat{R}}$ is the variance-covariance matrix from which we have extracted our factor solution for the measurement traits. Its last two rows and columns are entirely zeros. Ignoring them, the remainder of the matrix is analogous to an error matrix for a restricted linear model, as we now show.

Consider the typical element of $\hat{\hat{R}}$,

$$\begin{aligned} \hat{\hat{r}}_{jk} &= r_{jk} - a_{j1}\, a_{k1} - a_{j2}\, a_{k2} \\ &= r_{jk} - r_{p_{jS}}\, r_{p_{kS}} - r_{p_{jG}}\, r_{p_{kG}} \end{aligned}$$

where S is for Sex and G is for Grade. Note that

$$\begin{aligned} \hat{\hat{r}}_{jS} &= r_{p_{jS}} - a_{j1}\, a_{S1} - a_{j2}\, a_{S2} \\ &= r_{p_{jS}} - r_{p_{jS}} \cdot 1.00 - r_{p_{jG}} \cdot 0.00 \\ &= 0.00 \quad . \end{aligned}$$

and

$$\hat{\hat{r}}_{jG} = r_{p_{jG}} - a_{j1}\, a_{G1} - a_{j2}\, a_{G2}$$

$$= r_{p_{jG}} - r_{p_{jS}}\, \phi_{SG} - r_{p_{jG}}\, r_{p_{GG}}$$

$$= r_{p_{jG}} - r_{p_{js}} \cdot 0.00 - r_{p_{jG}} \cdot 1.00$$

$$= 0.00 \quad .$$

If we assume a standardized criterion variable z, then

$$\hat{\hat{r}}_{jk} = r_{jk} - [\, \bar{z}_{jM} \sqrt{N_M / N_F}\,]\ [-\bar{z}_{kF} \sqrt{N_F / N_M}\,]$$

$$- [\, \bar{z}_{j9} \sqrt{N_9 / N_{12}}\,][-\bar{z}_{k12} \sqrt{N_{12} / N_9}\,]$$

$$= r_{jk} + \bar{z}_{jM}\, \bar{z}_{kF} + \bar{z}_{j9}\, \bar{z}_{k12} \quad .$$

If the j, k means are correlated in the same direction with sex and grade, the addends must be negatives, since

$$N_F\, \bar{z}_{kF} = -N_M\, \bar{z}_{kM}$$

and

$$N_9\, \bar{z}_{k9} = -N_{12}\, \bar{z}_{k12}$$

etcetera, for all contrast, $k = 1, 2, \ldots, m$. Of course, if the means are uncorrelated with sex or grade the addends are zeros, and if the j, k means happen to be correlated with sex or grade in opposite directions one or both addends will be positive. The important point is that the sex correction to an element of total sample R turns out

to be a crossproduct of sex means on standardized variables, and the correction for grade turns out to be a crossproduct of grade means.

Consider the linear model in the restricted case of a 2 x 2 factorial design, balanced and without interaction, so that

$$N_{9M} = N_{9F} = N_{12M} = N_{12F} \quad ,$$

thus

$$N_M = N_F = N_9 = N_{12} = N_E \quad ,$$

and

$$N_M + N_F = N_9 + N_{12} = 2\ N_E = N \quad .$$

Recall that the basic relationship of the linear model without interaction is

$$W = T - B_{Sex} - B_{Grade}$$

or

$$w_{jk} = t_{jk} - b_{S_{jk}} - b_{G_{jk}} \quad .$$

For the standardized criterion z

$$w_{jk} = \sum_{i=1}^{N} z_{ji}\ z_{ki} - N_E\ (\bar{z}_{jM}\ \bar{z}_{kM} + \bar{z}_{jF}\ \bar{z}_{kF})$$

$$- N_E\ (\bar{z}_{j9}\ \bar{z}_{k9} + \bar{z}_{j12}\ \bar{z}_{k12})$$

and since $\bar{z}_{jM} = -\bar{z}_{jF}$ and $\bar{z}_{j9} = -\bar{z}_{j12}$

$$w_{jk} = N\, r_{jk} + N\, \bar{z}_{jM}\, \bar{z}_{kF} + N\, \bar{z}_{j9}\, \bar{z}_{k12} \quad .$$

Now, $\hat{\hat{D}}$, the pooled within groups dispersion estimate of the common population dispersion Δ on the null hypothesis of the linear model, has the j, kth element

$$\hat{\hat{d}}_{jk} = w_{jk} \,/\, (N - 4)$$

in our case. If we have very large subsamples, as we do, and are willing to treat N-4 simply as N, then

$$\hat{\hat{d}}_{jk} = r_{jk} + \bar{z}_{jM}\, \bar{z}_{kF} + \bar{z}_{j9}\, \bar{z}_{k12}$$

and this $\hat{\hat{D}}$ of the restricted linear model is the same as $\hat{\hat{R}}$ of our point biserial correlation model.

To summarize, we have shown that when we have large subsamples the residual matrix $\hat{\hat{R}}$ after extraction of sex and grade factors in the point biserial correlation model is analogous to the error dispersion matrix, or error variance-covariance matrix, $\hat{\hat{D}}$, of the special manova model with two dichotomous design variables, no interaction, balanced design. On the null hypothesis of this manova model,

$$H_0 : \quad \beta_M = \beta_F = 0,$$

$$\beta_9 = \beta_{12} = 0,$$

$$\Delta_{9M} = \Delta_{9F} = \Delta_{12M} = \Delta_{12F} = \Delta \quad ,$$

the matrix $\hat{\hat{D}}$ is the maximum likelihood estimator of Δ. The varimaxed principal components of $\hat{\hat{R}}$ we have adopted as a solution for the factor structure of the measurement traits in each of the domains of abilities and motives may be thought of as rotated components of the error covariance matrix in the restricted manova model specified. One important advantage of the point biserial method is that it does not require a balanced design for its execution, although certainly a nearly proportional design, such as the one in this research, is very desirable. The next section expones another advantage of the point biserial method.

XIII. LOCUS OF ORTHOGONALITY OF FACTORS

Factors of the error correlation matrix from the full linear model would be defined as linear components of the difference vector resulting from subtracting the cell centroid from the score vector of a subject in a cell. Each subject would be deviated from his own cell centroid and standardized in terms of the pooled within groups standard deviations. As a result, the cell centroid in the factor space would be a null vector for each cell. Every cell of the design would be located at the origin of the factor space. The differentiation of the subpopulations that existed in the original test space would be lost in the factor space. For example, even if boys had superior means on all mathematics tests, on a mathematics factor the boys' mean would equal the girls' mean, and both would be zero. This would be unrealistic and probably unacceptable to educators.

Factors on the point biserial correlation model are defined as linear components of the deviation of each subject's score vector minus the total sample centroid, and standardized in terms of total sample standard deviations. These factors will have a null vector as the total sample centroid, but each subpopulation sample will retain its unique location in the factor space. For example, the alignment of the samples for the four cells of our design in terms of means on two of our factors is as follows:

Sample	Mathematics Factor Mean	Hunting-Fishing Factor Mean
12th grade Males	.985	1.187
9th grade Males	.652	1.009
9th grade Females	-.633	-1.043
12th grade Females	-.956	-1.279

The picture we get from these Project TALENT findings is that boys outscore girls on the Mathematics factor, that boys as a group improve on the Mathematics factor over four years of high school, and the disturbing finding that twelfth grade girls as a group perform worse on the Mathematics factor than do ninth grade girls, even though the twelfth grade female population is substantially more able than the ninth grade female population in other respects, due to the combined influences of selective dropout and more education. The realistic location of the subpopulations in the factor space is an important virtue of the point biserial method solution.

It is within the subpopulations that the point biserial method factors are orthogonal, which is the same locus of orthogonality obtained for factors of the error matrix of the general linear model. That is where we want orthogonality, because that is the locus of the meaningful dispersion of traits of individual difference we have set out to orthogonalize. The total sample dispersion in the measurement space is bogus because of the influence on it of correlated parameters of the linear model, i.e., correlated group means. Since the factors of individual difference are to be orthogonal, the total sample correlations among the factors should be entirely due to and predictable from group means. This is the case with the point biserial method factors, as we now show by examples.

The general formula for predicting total sample correlations from subsample statistics and total sample means and standard deviations, as derived by M. Shaycoft, is

$$r_{xy.} = \frac{\sum_{i=1}^{g} p_i \, r_{xyi} \, s_{xi} \, s_{yi} + \sum_{i=1}^{g} p_i \, \overline{X}_i \, \overline{Y}_i - \overline{X}_. \, \overline{Y}_.}{s_{x.} \, s_{y.}}$$

where

g = number of subsamples

$p_i = N_i / N$, the ratio of subsample size to total sample size

$\overline{X}_i$, $\overline{Y}_i$, r_{xyi}, s_{xi}, s_{yi} are statistics for the ith subsample

$\overline{X}.$, $\overline{Y}.$, $s_{x.}$, $s_{y.}$, $r_{xy.}$ are statistics for total sample.

For our factors, since $r_{xyi} = 0$ and $\overline{X}. = \overline{Y}. = 0$, the formula simplifies to

$$r_{xy.} = \frac{\sum_{i=1}^{g} p_i \overline{X}_i \overline{Y}_i}{s_{x.} s_{y.}}$$

If we let X be the mathematics factor and Y be the hunting-fishing factor, the group means are as given above, with the values of p_i

Sample	$p_i = N_i/N$
9th M	.2806
9th F	.2761
12th M	.2197
12th F	.2236

and the total sample standard deviations

$s_{x.} = 1.2871$ $\qquad$ $s_{y.} = 1.5038$

Substituting these values in the simplified formula predicts that $r_{xy.} = .463$. By actual computation on 3,100 cases, $r_{xy.} = .453$.

For a second example, consider mathematics and English factors. The same $\overline{X}_1$, p_1, and $S_{x.}$ apply. Letting Y be the English factor, $S_{y.} = 1.3864$, and the group means are

9th F	1.041
12th F	.953
9th M	-.879
12th M	-1.043

Girls are better at English mechanics than boys, but the alarming finding is that ninth graders are better on this ability than are twelfth graders. The predicted $r_{xy.} = -.433$, and the actual data result is $r_{xy.} = -.433$.

The approach to this demonstration that the total sample correlations among the factors are due to correlated group means can be simplified by observing that the reduced version of Shaycoft's formula can be construed as a sum of products of point biserial correlations if the variables have zero grand means. We are going to ignore the very negligible observed correlations of the factors with the grade dichotomous design variable, and utilize only the point biserial correlations between sex and the factors. The result is that the total sample correlation of any pair of factors is practically the same as the product of the point biserials of the pair with sex. Here are some examples.

1) $\left.\begin{array}{l} r_{p_{\text{Math, Sex}}} = .613 \\ r_{p_{\text{H-F, Sex}}} = .744 \end{array}\right\}$ Product = .456

$r_{\text{Math, H-F}} = .453$

2) $r_{p_{\text{Eng, Sex}}} = -.705$; $r_{p_{\text{Color, Sex}}} = -.682$ — Product = .480 ; $r_{\text{Eng, Col}} = .466$

3) $r_{p_{\text{Math, Sex}}} = .613$; $r_{p_{\text{Color, Sex}}} = -.682$ — Product = -.418 ; $r_{\text{Math, Col}} = -.422$

4) $r_{p_{\text{Math, Sex}}} = .613$; $r_{p_{\text{Eng, Sex}}} = -.705$ — Product = -.432 ; $r_{\text{Math, Eng}} = -.433$

The indication is that correlated sex effects are quite important aspects of our factors, while correlated grade effects are not.

Factors are supposed to have unit variance. The locus of these unit variances in our solution is the same as the locus of the orthogonality. By actual computation the pooled within groups variances are a close approximation to a unit vector in each domain of factors.

Project TALENT prediction studies against follow-up criteria are almost always conducted on separate sex-grade subsamples, making it particularly convenient to have the factors of the 1960 measurement battery be orthogonal in sex-grade subpopulations. If we want to combine grades within one sex to build up sample size for a particular criterion study, we know what the rather negligible grade adjustments are to apply to the factors. It seems unlikely that there would ever be any justification for pooling sexes in a criterion study. Rather, a manova model with sex as a control design variable would be indicated in the case of a categorical criterion, and separate sexes regression studies would be preferable for a continuous criterion.

XIV. CANONICAL STRUCTURE BETWEEN DOMAINS

What a person can do and what he usually does or prefers to do stand in some relationship to each other. An important research

problem for the author has been to analyze the correlations between maximum performance traits and typical performance traits. Two assumptions that influenced the choice of a method of analysis were 1) that the structure of the relationships between domains could be revealed more clearly in terms of relationships between orthogonal factors of each domain than between a multitude of correlated measurement traits in each domain, and 2) that the structure of relationships between domains could be revealed more clearly if the disturbing influences of correlated sex and grade means were removed from the picture. To operationalize these assumptions, a pooled within sex-grade cells matrix of correlations among all factors of the reduced-rank models for both domains (22 factors in all) was computed for a random sample of 1,300 subjects, representing a 2 per cent sample of the total Project TALENT data files (after losses from incomplete data) for both sexes and grades 9 and 12. This matrix was abstracted from a four-cell discriminant analysis which also provided the clearest view of the sex and grade differences on the factors (reported in Chapter 7).

The canonical correlation model was employed in the analysis of this 22nd order correlation matrix. The purpose here is to give a brief description of the model for readers who are not familiar with it. A useful reference is Cooley and Lohnes (1962, Ch. 3). The derivation of the model may be studied in Anderson (1960, Ch. 12).

The bivariate correlations between pairs composed of one ability factor and one motive factor are interesting in themselves, but there are 121 such correlations available, which is an awful lot of correlations to try to think about simultaneously, if one is trying to generalize about the extent and nature of interrelationships of the domains. The canonical model uses the same analytic trick to display the structure of relationships across domains that the factor model uses to display the structure of relationships within a domain. That trick is to reduce the dimensionality to a few linear functions of the measures under study. The factor model selected linear functions of tests that had maximum variances, subject to restrictions of orthogonality. The canonical model selects linear functions that have maximum covariances between domains subject again to restrictions of orthogonality.

The best approach is to think of canonical analysis as a stepwise procedure. First, the model derives a component of each battery (domain of factors in our case) such that the covariance between the components is maximized. The conditions are

$$\mathbf{x} = \mathbf{c}' \zeta_1 \qquad \mathbf{y} = \mathbf{d}' \zeta_1$$

$$E(\mathbf{x}) = 0 \qquad E(\mathbf{y}) = 0$$

$$E(\mathbf{x}^2) = 1 \qquad E(\mathbf{y}^2) = 1$$

$$E(\mathbf{x}\ \mathbf{y}) \mid \text{maximum}$$

The differential calculus is employed in the derivation of the maximizing weights, c and d. The result for our sample, r_{xy}, is the maximum correlation that can be developed between a linear function of the ability factors and a linear function of the motives factors. This result is called the first canonical correlation. Besides the coefficient itself, interest centers on the interpretation of the canonical components, x and y. Which variables in each set contribute most heavily to the maximally correlated components? Once again, a pattern giving the correlations of the components with the variables on which they are defined is desired. The pattern for each set is easily arrived at:

$$\begin{aligned} a_1 &= E(\zeta_1\ \mathbf{x}) \\ &= E[\zeta_1\ (\mathbf{c}'\ \zeta_1)'] \\ &= E(\zeta_1\ \ \zeta_1'\ \mathbf{c}) \\ &= E(\zeta_1\ \ \zeta_1')\ \mathbf{c} \\ &= P_1\ \mathbf{c} \end{aligned}$$

and similarly

$$a_2 = E(\zeta_2\ \mathbf{y}) = P_2\ \mathbf{d} \quad .$$

The proportion of variance extracted from the first battery by the component x, given m_1 variables in the first battery, is $(a_1{}'a_1)/m_1$, and the proportion of variance extracted from the second battery by the component y is $(a_2{}'a_2)/m_2$, where m_2 is the number of variables in the second battery (in our case, $m_1 = m_2 = 11$).

The canonical model derives a pair of components that are maximally correlated subject to the restriction that they must be orthogonal to the first pair of components. If we now call the first canonical components x_1 and y_1, the second will be x_2 and y_2, and the conditions are:

$$x_2 = c_2{}'\,\zeta_1 \qquad y_2 = d_2{}'\,\zeta_2$$
$$E(x_2) = 0 \qquad E(y_2) = 0$$
$$E(x_2{}^2) = 1 \qquad E(y_2{}^2) = 1$$
$$E(x_1\,y_2) = 0 \qquad E(y_1\,x_2) = 0$$
$$E(x_2\,x_1) = 0 \qquad E(y_2\,y_1) = 0$$
$$E(x_2\,y_2)\mid \text{maximum} \quad .$$

Of course this second canonical correlation will be smaller than the first. It will have a pattern vector for each battery also. If this second canonical correlation is neither statistically insignificant nor trivially small, the model provides a third canonical relation for inspection, and so on up to the lesser of m_1 and m_2. In our case, we chose to report the four largest canonical correlations, which were only moderate themselves (.66, .45, .39, .34), and to ignore the other seven that ranged from .30 to .01. For k selected canonical relations a full interpretive report is provided by the k canonical correlation coefficients; the $m_1 \times k$ compounding coefficients for the first battery, C; the $m_2 \times k$ compounding coefficients for the second battery, D; the $m_1 \times k$ pattern for the first battery, A_1; and the $m_2 \times k$ pattern for the

second battery, A_2. Useful relationships in the sample space are:

$$A_1 = R_1 C$$

and

$$A_2 = R_2 D \quad .$$

The actual computation of the canonical correlation analysis involves the solution of a complicated eigenstructure problem, and we will only indicate the setup of the problem. Let the m_1 by m_2 matrix of cross correlations between the variables of the first set and those of the second set be called $\mathbf{R}_{12}$, and let R_{21} be its transpose. Remember that R_1 is the intercorrelations among the variables of the first set, and R_2 the intercorrelations among the second set. Then the problem is

$$(R_2^{-1} R_{21} R_1^{-1} R_{12} - \lambda_i I) d_i = 0 \quad ,$$

with the restriction

$$d_i' R_2 d_1 = 1 \quad .$$

Note that in forming the matrix product required we have gotten in hand the complete multiple correlation analysis of each variable of each set regressed in the space of all the variables of the other set, for the $m_2 \times m_1$ matrix

$$\beta_2 = R_2^{-1} R_{21}$$

contains as column vectors the beta weights for the regression of each

variable of set 1 (a column in β_2) on all the variables of set 2 (the rows of β_2). Likewise the $m_1 \times m_2$ matrix

$$\beta_1 = R_1^{-1} R_{12}$$

contains as columns the betas for the regression of each variable of set 2 (a column of β_1) on all the variables of set 1 (the rows of β_1). If we let $R_{1.2}$ be the m_1-element vector of multiple correlations of each test of set 1 with all tests of set 2, then

$$R_{1\cdot 2} = \{(\beta_2' R_{21})^{1/2}\} \text{ diag}$$

and correspondingly

$$R_{2\cdot 1} = \{(\beta_1' R_{12})^{1/2}\} \text{ diag}$$

where "diag" means that the vector to the left of the = sign is created from the diagonal elements of the matrix product to the right of the = sign. The "pattern" correlations of the m_1 variables in set 1 with the regression function defined on them for predicting the jth variable of set 2 can be computed by dividing each element of the vector of correlations of set 1 variables with the jth variable of set 2 by the multiple correlation between set 1 and the jth variable of set 2. Symbolically these pattern coefficients are the vector a_{1j},

$$a_{1j} = (1/R_{2\cdot 1_j}) \; R_{1j} \quad .$$

Correspondingly, the correlations of the m_2 variables in set 2 with the regression function defined on them for predicting the kth variable of set 1 is given as the vector a_{2k},

$$a_{2k} = (1/R_{1 \cdot 2_k}) \; R_{2k} \qquad .$$

We have seen that the weights d_i for the ith canonical component of set 2 emerge as the ith eigenvector of a matrix product. The corresponding weights for the ith canonical component of the set 1 variables is computed as

$$c_i = R_1^{-1} \; R_{12} \; d_i \; (1/\lambda_i) \qquad .$$

In this formulation the eigenvalue λ_i is the squared canonical correlation. The reason that the problem is complicated is that the matrix to be solved for its eigenstructure,

$$R_2^{-1} \; R_{21} \; R_1^{-1} \; R_{12} \qquad ,$$

is not symmetric. Of course, in our special case of factor variables, R_1 and R_2 are very nearly identity matrices. Although we did not employ the tactic, we suspect that it would be legitimate to treat these two factor intercorrelation matrices based on pooled within groups dispersion as identities, ignoring sampling anomalies, and solve the simple eigenstructure problem

$$(R_{21} \; R_{12}) \; D = D \; \Lambda$$

which involves a symmetric matrix.

What we have, then, is a model for representing the relationship between two sets of variables as k correlations between k components of the first set and k corresponding components of the second set, with all other correlations among components held to zero. For small sample studies k will be the number of statistically significant canonical correlations. For large sample studies such as ours, k will

be the number of significant canonical correlations judged to be nontrivial. We have chosen to judge correlations greater than .30 as nontrivial. The selected components of each set are interpreted in the light of their correlations with the variables of the set, given in the pattern A. The communalities for the variables for k components reveal how much of each variable is involved in the canonical structure solution. The sum of k proportions of generalized variance extracted by the components of each set gives an indication of the extent to which the entire set of variables is involved in the canonical structure. This is an important issue, because a very strong canonical correlation could be the result of a very high correlation of just one variable in one set with just one variable in the other set, and the remainder of the two sets could be essentially uninvolved in the canonical structure.

The canonical correlation model appears at first to be a complicated way of expressing the relationship between two measurement batteries. In fact, it is the simplest analytic model that can begin to do justice to this difficult problem of scientific generalization. A useful supplement to, but no substitute for, the canonical structure is provided by the multiple correlation analysis of each variable of each set regressed on all the variables of the other set.

XV. PREDICTING CATEGORICAL CRITERIA

Most of the criterion variables provided by the Project TALENT follow-ups are nominal variables, such as occupational classification or marital status. Prediction of such a categorical variable from the base of a multivariate measurement system such as our factors requires the employment of the multiple group discriminant analysis (or some discriminant function model), a model with which educators are still relatively unfamiliar. We are going to give a brief sketch of the model here. A fuller treatment is afforded in Cooley and Lohnes (1962, Ch. 4).

Once again, we have a model that derives linear functions of a battery suitable to doing a specific job. In this case the job for

the components is to predict membership in the cells of an external, categorical criterion variable. The model derives the components which best separate the cells or groups or subpopulations of the design in the measurement space of the predictors. These components are called discriminant functions. Again, the model can be viewed most easily as a stepwise procedure.

First, the model seeks the best discriminant function of the measurement vector z,

$$y = c' z$$

where both y and z are standardized. Recalling from our discussion of the general linear model that the matrix W is the pooled within groups sums of squares and crossproducts around group means, and the matrix B is the between groups s.s.c.p. of group means weighted by group sample sizes, the "best" discriminant function is afforded by that set of weights c such that

$$\lambda = \frac{c' B c}{c' W c} \Bigg| \text{ maximum}$$

subject to the restriction

$$c' R c = 1 \quad .$$

Again, a pattern for the function is

$$a = R c \quad .$$

Another interesting interpretive result is

$$r_{y,\ \text{criterion}} = \sqrt{\lambda / (1 + \lambda)}$$

giving a canonical correlation between the predictor variable component y and the criterion group variable coded as a set of binary dummy variables. There is a statistical significance test for this coefficient, which is in fact the multivariate analysis of variance test for a simple, one way manova.

Next, the model derives a second discriminant function which again maximizes λ subject to the requirement that this function be orthogonal to the first, and so on, with each new function required to be orthogonal to all the previous ones. The complete eigenstructure problem involved may be coded as

$$(W^{-1} B - \lambda_i I) c_i = 0 \quad ,$$

or as

$$(W^{-1} B) C = C \Lambda \quad .$$

This is again a nonsymmetric matrix problem. When the number of groups, g, is equal to or less than the number of predictors, m, the rank of $W^{-1} A$ is g-1, and there are only g-1 nonzero eigenvalues, and thus only g-1 discriminant functions. You can see the sense of this if you consider that two groups must be colinear with respect to their centroids in a space of any number of dimensions, and three groups must be coplanar in any measurement space of two or more dimensions, however many, and so forth.

If k discriminant functions are to be preserved, the most important interpretive result is again the m x k pattern

$$A = R C \quad .$$

Again, the row sums of squares in A give communalities for the variables and the column sums of squares divided by m give proportions of variance extracted from the battery.

Frequently the discriminating power of the components will be demonstrated by computing group classification statistics for a replication sample of new subjects and tabulating the hits (correct classifications) and misses achieved. For this purpose the compounding coefficients are applied to the factor score vectors of the new subjects, and discriminant scores are created. The classification model may be studied in Cooley and Lohnes (1962, Ch. 7).

XVI. WEIGHTED VERSUS UNWEIGHTED ACCUMULATIONS

A final point about research methods is necessitated by the fact that the Project TALENT sample was designed as a stratified probability sample with different sampling ratios for the strata, rather than as a simple random sample. As a result of this design, researchers who desire to estimate population parameters are obliged to apply the differential sampling weights to statistical accumulations. Without going into details we wish to record that the correlations on which our factor analyses have been based were derived from properly weighted accumulations.

It has been the practice at Project TALENT to ignore sampling weights in computing accumulations for prediction studies. This is because only about half the subjects respond on any follow-up from which a criterion variable may be taken, and of course the respondent-nonrespondent split is anything but random. In this situation it is not possible to estimate parameters of the original population anyway. Thus we expect to have factors of the measurement battery that were derived from weighted accumulations regularly employed in prediction studies where the sampling weights are not used.

There is no real problem, however. Experience has shown us that numerical differences due to weighting or not weighting are quite small, and are comparable to differences resulting from other anomalies, such as the exclusion of subjects with missing data. The reality is that we cannot expect and do not need to achieve an exact N(0,I) distribution for our factors in any study in which we utilize them. We know they are theoretically standardized and uncorrelated, and we can

use our best jdugment in deciding how to treat the departures from expectations in any particular sample.

We have described in this chapter a fairly complete multivariate statistical strategy for researching in a trait and factor psychology. We have not described the computer programs which have evolved at Project TALENT that implement this strategy and are the actual weapons of our struggle with our data, but we do have the programs, and stand ready to share them with others.

Chapter Three

EDUCATIONAL ACHIEVEMENT TRAITS

The factor analytic research on the structure of adolescent abilities began with intercorrelations among 60 surface traits and emerged with 13 uncorrelated source traits. The resulting factors can only be understood in terms of their content by careful attention to the contents of the several or many tests that contribute significantly to the composition of each factor. There is so much detail to present on the 60 ability indicators that the material has been divided into two chapters. This chapter begins with an overview of the factor solution for the abilities domain, and then describes in detail the compositions of the three factors that represent core educational achievement traits: Verbal Knowledges, English Language, and Mathematics. The next chapter discusses the compositions of three differential aptitude factors and five specialized knowledge factors. Chapter Seven analyzes the control factors of Sex and Grade in detail.

An overview of the factor solution for the abilities domain of Project TALENT tests can be gained from three tables. Table 3.1 names the 13 ability factors, and gives their mnemonics and the percentage of the generalized variance extracted from the 62 variable total sample correlation matrix by each (60 tests plus point biserials with Sex and Grade). The factors have been arrayed in their order of importance as explanatory concepts for the correlation matrix. Table 3.2 names the 60 abilities tests of the TALENT battery, with their mnemonics and code numbers. We do not use the code numbers in this discussion, but they are used heavily in other Project TALENT research monographs. Table 3.3 reports the meaningful coefficients from the factor pattern and structure matrix, as well as the communalities after 13 factors for the 60 tests. The reader is reminded that the factoring method guaranteed communalities of 1.00 for the Sex and Grade indicators. Note that only correlations between tests and factors greater than or equal to .35 have been reported as meaningful. A factor loading less than .35 indicates less than

Table 3.1

Abilities Domain Factors

Mnemonic	Factor Name	Variance Extracted
VKN	Verbal Knowledges	18.7 %
GRD	Grade	7.8 %
ENG	English Language	6.6 %
SEX	Sex	5.7 %
VIS	Visual Reasoning	5.3 %
MAT	Mathematics	4.1 %
PSA	Perceptual Speed and Accuracy	3.6 %
SCR	Screening	3.3 %
H-F	Hunting-Fishing	2.2 %
MEM	Memory	2.1 %
COL	Color, Foods	1.9 %
ETI	Etiquette	1.6 %
GAM	Games	1.5 %

(13 factors extract 64.6% of variance)

Table 3.2

60 Abilities Domain Variables

	Mnemonic	Code	Name of Test
1	SCR	R-101	Screening
2	VOC	R-102	Vocabulary
3	LIT	R-103	Literature
4	MUS	R-104	Music
5	SST	R-105	Social Studies
6	MAT	R-106	Mathematics
7	PHY	R-107	Physical Sciences
8	BIO	R-108	Biological Sciences
9	SCA	R-109	Scientific Attitude
10	AER	R-110	Aeronautics and Space
11	ELE	R-111	Electricity and Electronics
12	MEC	R-112	Mechanics
13	FAR	R-113	Farming
14	HEC	R-114	Home Economics
15	SPO	R-115	Sports
16	ART	R-131	Art
17	LAW	R-132	Law
18	HEA	R-133	Health
19	ENG	R-134	Engineering
20	ARH	R-135	Architecture
21	JUR	R-136	Journalism
22	FOT	R-137	Foreign Travel
23	MIL	R-138	Military
24	ACC	R-139	Accounting
25	PRK	R-140	Practical Knowledge
26	CLE	R-141	Clerical
27	BIB	R-142	Bible
28	COL	R-143	Colors
29	ETI	R-144	Etiquette
30	HUN	R-145	Hunting
31	FIS	R-146	Fishing
32	OUT	R-147	Outdoor Activities (other)
33	PHO	R-148	Photography
34	GAM	R-149	Games (sedentary)
35	THR	R-150	Theater and Ballet
36	FDS	R-151	Foods
37	MIS	R-152	Miscellaneous

Table 3.2 (continued)

	Mnemonic	Code	Name of Test
38	MMS	R-211	Memory for Sentences
39	MMW	R-212	Memory for Words
40	DSW	R-220	Disguised Words
41	SPL	R-231	Spelling
42	CAP	R-232	Captialization
43	PNC	R-233	Punctuation
44	USG	R-234	English Usage
45	EXP	R-235	Effective Expression
46	WDF	R-240	Word Functions in Sentences
47	RDG	R-250	Reading Comprehension
48	CRE	R-260	Creativity
49	MCR	R-270	Mechanical Reasoning
50	VS2	R-281	Visualization in Two Dimensions
51	VS3	R-282	Visualization in Three Dimensions
52	ABS	R-290	Abstract Reasoning
53	ARR	R-311	Arithmetic Reasoning
54	MA9	R-312	Introductory Mathematics
55	ADV	R-333	Advanced Mathematics
56	ARC	R-410	Arithmetic Computation
57	TBL	R-420	Table Reading
58	CLR	R-430	Clerical Checking
59	OBJ	R-440	Object Inspection
60	PRF	A-500	Preferences

Table 3.3

Abilities Domain Variable-Factor Correlations ≥ .35

Test	VKN	GRD	ENG	SEX	VIS	MAT	PSA	SCR	H-F	MEM	COL	ETI	GAM	h^2	R^2
SCR								61						64	40
VOC	66													79	78
LIT	69	42												76	73
MUS	65													63	59
SST	70													77	76
MAT	45					62								82	75
PHY	54					42								74	71
BIO	51													63	56
SCA	47													52	49
AER	50			42										63	57
ELE	36			44										69	64
MEC				52				38						74	69
FAR	36							47						65	50
HEC				-52										66	59
SPO	48			39										57	55
ART	72													68	63
LAW	61	35												58	53
HEA	56													60	56
ENG	39													48	42
ARH	53													40	33
JUR	58													49	45
FOT	68													57	50
MIL	59													51	38
ACC	54	39												54	53
PRK	47													58	46
CLE		53												51	48
BIB	63													60	45
COL											66			65	27
ETI												71		79	21
HUN				43					58					59	34
FIS									77					74	23
OUT	50													55	49
PHO	41													40	30
GAM	41												46	53	29
THR	65													64	60
FDS	46										51			59	35
MIS	63													56	52
MMS										83				86	20
MMW										50				57	38
DSW	46		40											65	58
SPL			58											67	56
CAP			62											59	43
PNC	38		60											75	69
USG	36		59											62	54
EXP			53											57	46
WDF	40		42											66	58
RDG	65	35	39											81	79
CRE	46				41									57	53
MCR				44	59									73	66
VS2					63									57	36
VS3					71									66	49
ABS					57									64	54
ARR	41		39											66	63
MA9	39		36			61								79	73
ADV						71								69	46
ARC			46				36							67	54
TBL							71							59	36
CLR							76							65	38
OBJ							67							62	35
PRF							56	35						64	18

12 per cent variance overlap between the test and the factor, which it seems to the author to be wise to ignore. Although $a_{jk} \geqq .35$ represents a completely arbitrary standard for reporting loadings, it must be admitted that some such standard has to be adopted to permit the unobstructed viewing of the important features of the factor solution.

What are the salient features of the solution which has been adopted from among the infinity of possible orthogonal factor solutions for the abilities domain? First, a very substantial reduction in rank has been accomplished, yet the 13 factors account for 65 per cent of the generalized variance of the 62nd order correlation matrix. That the reduced rank solution gives a fairly tight fit to the data is apparent from Table 3.4, in which the off-diagonal elements of the residual, or error matrix

$$R_{res} = R - AA'$$

after extraction of 13 factors are distributed. The distribution is nicely symmetrical around a mean of almost exactly zero, and approximately 95 per cent of the errors are less than .05 in absolute value. The standard deviation of this distribution of errors of fitting compares favorably with the standard error of the correlation estimates in R, so that there is about the same precision in the fit of the reduced rank factor model as there is in the sample estimates of population correlation parameters.

Second, a remarkable feature is that for every single surface trait the obtained communality is higher then the Guttman lower bound given by the multiple correlation of the indicator with the best composite of the other 61 indicators. The final column of Table 3.3 presents these multiple correlations where they may be easily compared with the achieved communalities. This feature would seem to support the contention that enough factors have been extracted. Also, it should be noted that the last two factors, ETI and GAM, have meaningful loadings on only one indicator and look like specific factors, which suggests that the common factors have all been found.

Table 3.4

Off Diagonal Terms (Upper Triangle) of R-AA′

Lower Limit of Class Interval	Frequency
.00	0
.19	0
.18	0
.17	0
.16	0
.15	0
.14	0
.13	0
.12	0
.11	0
.10	1
.09	2
.08	3
.07	2
.06	5
.05	14
.04	20
.03	32
.02	89
.01	182
-.00	458
-.01	391
-.02	319
-.03	183
-.04	82
-.05	46
-.06	23
-.07	13
-.08	7
-.09	5
-.10	3
-.11	4
-.12	4
-.13	0
-.14	0
-.15	0
-.16	0
-.17	0
-.18	0
-.19	0
-.20	3

N	1891
Mean	-.0056
S.D.	.0246

Third, appreciation is due to Kaiser's Varimax rotation for the superb heuristic display on these data. The three educational achievement factors and the three differential aptitude factors located correspond to the major factors of intellect that have been found repeatedly in previous studies, and provide a comprehensive inventory of key intellectual traits. Of course, much of the credit for this comprehensiveness belongs to the psychometricians who designed the TALENT battery, but the Varimax method was able to locate orthogonal factors with optimal psychological meaningfulness, in the teeth of the assertions of partisans of obliquity to the effect that factors in a structure of intellect cannot be both orthogonal and construct valid. The cleanness of the Varimax factor pattern is also noteworthy. This looks very much like the classical notion of a simple structure. Few of the tests are meaningfully loaded on more than one factor, and all the factors except Verbal Knowledges are defined in terms of a small number of tests. The multiplicity of indicators for VKN is a major research finding to be discussed below.

The decision to pool Sex and Grade samples for this research was not made lightly. Clearly, a structural theory of adolescent personality has much greater likelihood of practical application as a measurement solution for secondary education if it postulates one set of dimensions for all adolescents, avoiding the engineering difficulties of a school measurement and recording system involving a different set of variables for each sex-grade group. However, Sex and Grade differences in intellectual performances are known to be real and important, and the author's effort to justify a postulate that explains these differences in terms of the parameters of a linear model, while ingeniously simplifying, does ingenuously ignore the respectable theory ot developmental emergence of intellectual structure from a global, infantile g. Our linear model theory assumes a constant correlational structure for intellectual traits at least throughout adolescence. The developmental theory assumes that correlational bonds among intellectual traits are systematically weakening during adolescence. What evidence have we to support our approach?

Prior to pooling of the data from the four design cells, separate factor analyses were conducted for each of the sex-grade subsamples. Using the rule of thumb that says that principal components associated with eigenvalues smaller than unity may usually be ignored, a decision to retain eight factors in each analysis was reached. Table 3.5 presents the eight factors for each sample obtained from the Varimax operation, arranged for ease of comparison across samples. The four factor patterns are not identical, of course, but they are very similar. The three core educational achievement factors are easily recognized in all subsamples, and two of the three differential aptitudes, Visual Reasoning and Perceptual Speed and Accuracy, appear quite clearly in all subsamples. That Memory, the third aptitude factor, fails to appear is undoubtedly a result of under-factoring. There are differences among subsamples on the less important factors, but the evidence of very similar primary explanatory constructs (VKN, ENG, VIS, PSA, MAT) seems to justify the quest for a single structure for adolescent personality.

An alternative analytical approach to the selected procedure of passing arbitrary factors precisely through Sex and Grade and not rotating these control factors would have been to simply rotate a set of principal components of the 62nd order total sample matrix and allow the Sex and Grade Indicators to load on whatever factors they wanted to. Whichever factors then had sizeable Sex or Grade loadings would be the ones that were importantly perturbed by the influence of correlated linear model parameters. Some readers may feel that this would have been the preferred analytical approach, and may wonder to what extent the author's results are artifacts of his method. Table 3.6 lists in order of importance the 11 rotated components of the total sample correlation matrix arrived at by this alternate method (11 to correspond to the 11 components that were Varimax rotated in the official solution). Table 3.7 reports the factor pattern, with the communalities. Note that the obtained, unforced Sex h^2 is .794 and the obtained, unforced Grade h^2 is .801, whereas in the official solution these communalities

Table 3.5

Varimax Components of 60 Ability Domain Variables in Separate Sex-Grade Cells (8 Factors Rotated)

FA1: Verbal Knowledges

High Loadings

Sample	Variance	VOC	LIT	MUS	SST	ART	THR	RDG
9 M	13.8	71	76	70	74	74	70	67
12 M	12.7	68	77	67	73	74	70	66
9 F	8.6	56	63	59	57	64	63	54
12 F	11.4	71	74	70	67	74	72	65

FA2: English Language

High Loadings

Sample	Variance	SPL	CAP	PNC	USG	EXP	ARC	MMW
9 M	6.0	62	65	65	62	57	58	44
12 M	4.1	57	64	60	63	59	52	42
9 F	6.1	66	54	69	57	49	55	57
12 F	5.2	65	62	67	61	56	51	54

FA3: Visual Reasoning

High Loadings

Sample	Variance	MCR	VS2	VS3	ABS
9 M	4.1	71	61	74	61
12 M	4.4	72	62	73	55
9 F	3.3	63	61	71	58
12 F	3.8	66	65	71	57

Table 3.5 (continued)

FA4: Field and Farm Knowledges

Sample	Variance	MEC	FAR	HUN	FIS	PHY	BIO	ELE	BIB
		High Loadings							
9 M	3.2	55	56	69	57	30	39	38	--
12 M	3.0	48	65	72	61	22	42	27	--
9 F	4.7	56	58	--	--	60	58	60	31
12 F	1.6	35	39	--	--	31	36	33	38

FA5: Perceptual Speed and Accuracy

Sample	Variance	TBL	CLR	OBJ	PRF
		High Loadings			
9 M	2.3	69	75	68	59
12 M	2.4	75	78	67	52
9 F	2.3	73	75	69	61
12 F	2.4	75	77	66	58

FA6: Mathematics

Sample	Variance	ADV	MAT	ARR	MA9	PHY
		High Loadings				
9 M	1.6	70	43	27	39	22
12 M	4.2	73	70	51	72	50
9 F	1.1	88	24	--	20	--
12 F	3.4	73	71	37	70	50

Table 3.5 (continued)

FA7: Unusual Knowledges

Sample	Variance	High Loadings				
		COL	HEC	FDS	HUN	FIS
9 M	1.1	76	11	28	--	--
12 M	1.5	72	43	34	--	--
9 F	1.2	--	--	--	60	74
12 F	1.4	--	--	--	59	70

FA8: Screening

Sample	Variance	High Loadings		
		SCR	PRK	CLE
9 M				
12 M	2.2	50	38	46
9 F	3.5	60	52	36
12 F	3.0	64	49	59

Table 3.6

Althernative Varimaxed Components
of the Abilities Domain Total R

Mnemonic	Factor Name	Variance Extracted
VKN	Verbal Knowledges	18.7 %
ENG	English Language	9.1 %
VIS	Visual Reasoning	6.6 %
MAT	Mathematics	4.2 %
H-F	Hunting-Fishing	4.1 %
PSA	Perceptual Speed and Accuracy	4.0 %
COL	Color, Foods, Etiquette	3.9 %
GRD	Grade	3.1 %
SCR	Screening	2.5 %
MEM	Memory	2.1 %
GAM	Games	2.1 %

(11 factors extract 62.9% of variance)

Table 3.7

Abilities Domain Variable-Factor Correlations ≥ .35

Test	VKN	ENG	VIS	MAT	H-F	PSA	COL	GRD	SCR	MEM	GAM	h^2
SCR									57			64
VOC	73											79
LIT	75											75
MUS	67											63
SST	74											77
MAT	53			63								81
PHY	60			38								75
BIO	58											63
SCA	49											52
AER	59		35									62
ELE	49		40									66
MEC	45		42		47							74
FAR	40								43			64
HEC							57		36			71
SPO	56											60
ART	73											68
LAW	65											58
HEA	57											60
ENG	47											47
ARH	54											40
JUR	61											50
FOT	72											58
MIL	61											48
ACC	59											58
PRK	47										39	58
CLE								59				64
BIB	58											49
COL							62					51
ETI							43				42	49
HUN					72							60
FTS					78							65
OUT	52											55
PHO	38											39
GAM	44										52	55
THR	65											64
FDS	51						43					50
MIS	65											57
MMS										89		85
MMW		37								48		56
DSW	47	46										64
SPL		67										67
CAP		69										59
PNC	37	69										75
USG	36	66										62
EXP		61										57
WDF	38	49										64
RDG	66	46										80
CRE	50		43									57
MCR	37		68									74
VS2			65									57
VS3			73									66
ABS		38	57									64
ARR	44		35	36								66
MA9	42	37		61								79
ADV				74								71
ARC		52				37						66
TBL						73						60
CLR						78						63
OBJ						69						62
PRF						56			39			59
SEX					-50		57					79
GRA								81				80

are both unity. Note that in this solution 11 factors account for 63 per cent of the generalized variance, while 13 factors (including Sex and Grade) accounted for 65 per cent of the variance in the official solution. This is consistent with the derivational property of a principal components solution that it maximizes the variance extracted by a set of k components, and provides one good argument in favor of the alternative approach. Note that the communalities are very similar to those for the official approach for the 60 tests. An interesting finding is that it takes exactly 11 factors to bring every single communality above its least lower bound as provided by its multiple correlation analog. Finally, the ghost of artifactuality is laid by the superb agreement between the official and the alternative analyses. The six major factors are completely recognizable in the alternative analysis, as is every minor factor except Etiquette, which has merged with Color, Foods. The Grade indicator has defined a factor on its own, and the Sex indicator has been split between a masculine factor of Hunting-Fishing Knowledges and a feminine factor of Color, Foods, Etiquette, and Home Economics Knowledges. This alternative is a good solution. The official solution is preferred because its pattern is cleaner and because the locus of orthogonality is within each sex-grade cell where the author wants it to be. The main point is that the measurement traits are seen to have a very strong primary structure which will "out" almost regardless of method or sample.

As a final demonstration of the robustness of the inherent structure of the data, a second alternative to the selected procedure is reported. This alternative consists of factoring the "error correlation matrix" of the complete linear model (i.e., with sex, grade, and interaction effects removed). The error correlation matrix is based on pooled sums of squares and cross-products of deviations from sex-grade cell means, as described in Chapter Two, Section Eleven. Constant effects of sex, grade, and interaction have been removed from this matrix and cannot appear in the factor solution. Table 3.8 lists the 11 Varimaxed components that were extracted from the error matrix, and Table 3.9 contains the factor pattern, communalities, and corresponding squared multiple correlations. The six major factors of the official solution

Table 3.8

Alternative Varimaxed Components of the Pooled Within Sex-Grade Cells R

Mnemonic	Factor Name	Variance Extracted
VKN	Verbal Knowledges	19.0 %
ENG	English Language	7.8 %
VIS	Visual Reasoning	6.0 %
SCR	Screening	5.1 %
MAT	Mathematics	4.5 %
PSA	Perceptual Speed and Accuracy	3.9 %
GAM	Games	3.6 %
COL	Color, Foods	2.5 %
H-F	Hunting-Fishing	2.4 %
MEM	Memory	2.3 %
MMW	Memory for Words	1.8 %

(11 factors extract 58.8% of variance)

Table 3.9

Abilities Domain Variable-Factor Correlations $\geq .35$

Test	VKN	ENG	VIS	SCR	MAT	PSA	GAM	COL	H-F	MEM	MMW	h^2	R^2
SCR				50			35					59	37
VOC	67											77	75
LIT	76											72	67
MUS	65											60	56
SST	72											75	73
MAT	47				65							79	72
PHY	55			38	41							72	68
BIO	54			41								60	51
SCA	46											47	44
AER	55											58	46
ELE	37			45	36							67	52
MEC				58								65	52
FAR				58								62	46
HEC				54								57	38
SPO	53											48	42
ART	69											66	61
LAW	62											51	45
HEA	53											55	51
ENG												43	35
ARH	51											36	30
JUR	56											44	40
FOT	69											54	47
MIL	62											45	30
ACC	53											46	44
PRK	40						51					55	41
CLE							44					38	24
BIB	63											54	43
COL								69				58	19
ETI												65	17
HUN									73			60	16
FTS									77			63	14
OUT	45											51	46
PHO							47					39	26
GAM	39						44					43	26
THR	64											60	55
FDS	44							50				52	31
MIS	60											53	49
MMS										86		81	18
MMW										54	71	56	34
DSW	44	43										62	54
SPL		66										63	47
CAP		64										55	39
PNC	37	65										72	65
USG	35	63										59	49
EXP		58										53	39
WDF	41	44										62	54
RDG	66	42										78	76
CRE	44		42									54	49
MCR			67									68	55
VS2			64									55	33
VS3			72									63	45
ABS			58									63	52
ARR	39	41			35							63	60
MA9	39	37			62							78	71
ADV					77							66	37
ARC		47				37						64	50
TBL						73						56	31
CLR						77						62	35
OBJ						68						59	33
PRF						58						54	18

are again present (VKN, ENG, MAT, VIS, PSA, MEM) in the same order of importance and with very similar percentages of variance extracted. Among the factors of less educational significance, H-F and COL are the same as in the official solution. SCR and GAM have become more generalized, and a new special factor, MMW, has replaced the ETI factor of the official solution. However, nearly unique factors such as ETI or MMW serve primarily to reassure us that sufficient factors have been extracted. The squared multiple correlations for this solution are of course lower than for the official solution because the pooled within cells correlations are not inflated by correlated Sex and Grade differences. The squared multiple correlations of Table 3.9 are of interest because they estimate the extent to which each ability indicator can be predicted from a best composite of the other 59 ability indicators within any sex-grade subsample. Vocabulary and Reading Comprehension are the most predictable indicators, while Colors, Hunting, Fishing, Memory for Sentences, and Preferences are the least predictable.

The author hopes that this overview of the selected factor solution for the abilities domain tests, set as it has been against a backdrop of outcomes of alternative procedures, has persuaded the reader that the selected source traits are for the most part strongly prefigured in the interrelationships among the surface traits, and are not to be viewed as artifacts of method. As we now go ahead into detailed discussion of the selected factors we will attempt to show that the three core educational achievement factors--Verbal Knowledges, English Language, Mathematics-- and the three differential aptitudes--Visual Reasoning, Perceptual Speed and Accuracy, Memory--are quite consistent with the trends in the literature of factor analyses of abilities tests, and that they represent a reasonably comprehensive set of theoretical concepts for an educational measurement model of adolescent intellect.

II. EDUCATIONAL ACHIEVEMENT FACTORS

I. VERBAL KNOWLEDGES

Far and away the most important explanatory construct of the selected theory for the intercorrelations among the 60 abilities indicators is Verbal Knowledges (VKN). This source trait accounts for more of the generalized variance in the system of observations than do the next three constructs in importance (ENG, VIS, MAT) taken together, and almost as much as these three plus PSA. Whereas each of the other factors is meaningfully loaded on only a few of the indicators, this pervasive factor is meaningfully loaded on 37 of the 60 tests. That is, 37 different ability tests of the TALENT battery correlate .35 or higher with VKN. There are 26 tests for which VKN is the most important source trait. We are going to describe each of these 26 indicators of VKN separately in order to give a detailed picture of the content of the factor, but first we offer a few generalizations about Verbal Knowledges.

VKN is our closest approximation to General Intelligence, or I.Q. Technically, VKN is a _g_ factor, since every single one of the 60 ability tests has a positive nonzero correlation with this factor. In Chapter One it was emphasized that Spearman insisted on the "purely formal character" of _g_, saying: "It consists in just that constituent--whatever it may be--which is common to all the abilities...." (Spearman, 1904) He defined _g_ not by what it is, but by where it can be found. The only requirement is that _g_ must "enter into all abilities whatsoever." VKN satisfies this requirement. However, we hasten to acknowledge that many somewhat different _g_ factors could be extracted from our battery, and many readers would prefer the first principal component of the battery to our VKN as a _g_ factor. We did, in fact, at one stage in the research extract the first principal component, set it aside as _g_, and then Varimax-rotate a set of the remaining principal components. The resulting group factors did not appear to be as interpretable as those arrived at in our now "official" solution. The only sense, then, in which VKN is the "best" _g_ factor for our data is that in our judgment the overall solution of which it is a part is "best."

Nevertheless, it was from the onset our design to emerge with a set of orthogonal factors arranged in a hierarchy of importance, after the fashion of the British analysts, in which the top of the hierarchy would be a g factor, and VKN provides such a construct.

Why not call this predominant factor General Intelligence? What virtue resides in the name Verbal Knowledges? Mainly, the answer is that intelligence is a term that is much more susceptible to misunderstanding than is knowledge. The author has explicated the meaning of intelligence for the psychological tradition to which he owes allegiance in Chapter One, but not all psychologists and educators operate within the conventions of that tradition, and intelligence has a plethora of unwanted connotations in other theoretical and historical contexts. The problem might be said to be the surplus meanings of intelligence. In contrast, knowledge has not figured as a concept name in much psychological theorizing, and it has an ordinary language sense which is just what the author desires to emphasize in the interpretation of the g factor.

We have defined a knowledge as a performance set that enables the subject to reproduce associations or to complete gestalts from a broad class of cognitive holdings, or concepts. In this sense, a knowledge is a package of related abstractions. What relates the concepts in the package is that they are all about the same special part of the world of experience, or the phenomenal field. We call such a part of the world a subject-matter area, and we often call concepts by the term information when they are primarily descriptive rather than analytical in nature. Therefore, our alternative definition of a knowledge trait is that it is an ability to generate and apply information about a subject-matter area. It must be noted that subject-matter areas are arbitrarily defined by social conventions, and that knowledges are not necessarily psychologically discrete. Hence a knowledge trait is a surface trait or indicator.

Actually, the most significant research finding from our studies is that 25 varied information tests in the TALENT battery represent surface traits that are so strongly and consistently interrelated that one source trait pretty much accounts for them all. Table 3.10 lists

Table 3.10

Correlations Among VKN Factor Indicators
(Pooled Within R above Diagonal; Total R below Diagonal)

Test	ELE	ENG	PHO	PRK	SCA	SPO	OUT	AER	BIO	ARH	ACC	PHY	HEA	JUR	MIL	LAW	MIS	BIB	RDG	THR	MUS	VOC	FOT	LIT	SST	ART	VKN
ART	40	43	39	48	48	46	50	46	48	43	51	52	55	49	41	52	56	47	65	61	60	65	55	65	63		72
SST	48	44	38	48	54	56	53	50	58	44	54	67	59	53	46	58	59	55	73	57	63	74	60	71		64	70
LIT	44	39	35	42	50	50	48	50	54	46	50	61	53	50	45	53	57	54	69	60	64	70	58		74	67	69
FOT	36	35	29	37	40	42	41	42	44	38	42	49	45	42	39	46	48	42	56	50	52	57		60	63	56	68
VOC	54	48	40	49	58	53	56	55	60	45	56	69	60	53	43	57	57	54	75	62	64		60	74	77	66	66
MUS	41	37	33	40	44	48	45	45	48	41	46	54	50	47	39	47	52	44	61	57		65	52	66	63	62	65
THR	36	38	36	46	45	46	46	42	42	39	49	47	51	49	39	50	51	43	61		61	62	49	63	57	64	65
RDG	46	45	42	51	58	51	54	51	57	43	53	63	60	53	42	57	57	58		65	64	76	57	73	74	67	65
BIB	32	33	30	37	41	36	39	37	43	36	38	47	44	38	35	45	46		60	46	47	55	43	57	57	50	63
MIS	41	39	36	44	52	44	39	42	45	39	46	52	51	45	39	46		48	59	52	53	61	50	59	62	58	63
LAW	39	38	33	41	42	42	44	43	44	35	48	49	48	43	39		50	48	61	52	49	63	50	60	63	54	61
MIL	30	28	28	29	28	37	34	37	32	30	34	37	35	34		46	43	36	45	39	40	50	44	49	52	42	59
JUR	34	35	31	39	38	41	39	37	38	34	45	44	45		38	49	48	42	58	53	51	57	45	56	57	53	58
HEA	40	43	38	48	46	43	49	41	49	35	47	51		50	36	51	53	48	65	56	54	62	46	58	60	58	56
PHY	63	44	32	38	48	45	49	54	61	39	45		47	43	43	51	53	46	59	42	50	69	52	58	68	50	54
ACC	38	36	29	41	43	40	42	39	40	35		44	53	51	41	55	49	45	61	56	51	61	46	59	57	55	54
ARH	32	30	25	29	31	33	34	34	34		39	39	38	38	33	39	41	38	47	42	44	48	40	50	47	46	53
BIO	46	39	29	33	45	39	.45	45		37	45	63	50	42	39	50	49	45	59	42	48	65	49	58	63	50	51
AER	54	37	30	33	38	38	41		50	33	36	60	34	35	44	46	43	34	45	32	38	56	46	46	53	41	50
OUT	41	43	35	45	43	42		45	50	36	46	52	50	42	39	49	50	40	56	45	46	60	45	51	57	51	50
SPO	31	33	29	39	40		47	50	47	34	42	52	39	42	46	49	46	35	49	40	43	57	47	51	61	43	48
SCA	37	34	32	40		40	46	36	49	35	50	47	51	44	33	47	45	44	63	50	48	61	43	56	57	51	47
PRK	32	38	34		46	39	47	31	37	33	47	37	53	44	33	46	47	40	55	51	44	53	39	48	51	51	47
PHO	30	31		39	37	30	37	28	32	29	38	32	43	35	28	38	37	33	47	40	37	44	32	40	41	42	41
ENG	40		33	40	38	42	48	44	46	33	41	49	43	38	36	44	43	35	47	37	38	53	40	43	49	44	39
ELE		47	28	30	36	46	45	63	51	31	37	67	33	33	39	44	42	29	41	27	34	55	41	42	51	36	36

these 25 information tests and reports their common or shared source in terms of their loadings on VKN, as well as their intercorrelations both for total sample and for any sex-grade cell (as estimated from the pooled within-cells R matrix). It also lists RDG, or Reading Comprehension, which is the only indicator outside the information tests that has its most important loading on VKN.

This long list of tests indicating primarily VKN illustrates what Spearman spoke of as "the indifference of the in icator," meaning that there are many ways of measuring g. The moderate to strong correlations among these many indicators bear out what Vernon has called the "unavoidable" nature of g as an explanatory construct for the abilities domain. There is substantiation here for Fleishman's notion of abilities in the first instance as "capacities for utilizing different kinds of information." (1965, p. 6) The leading role of information tests in defining g in this research is also foreshadowed by Flanagan's summarization of the wartime testing research in the Army Air Force, in which he concluded that the General Information Test was the best test in the battery for overall predictive validity. That test "measured the individual's knowledge of special types of activities." (1948) We will balance this emphasis on VKN as a construct of general intelligence by arguing that it is also a construct with rather comprehensive curriculum validity after our review of the actual content of the factor.

The information test that correlates highest with VKN is Art. Of the 12 items on the Art scale, five asked technical questions about art materials and methods ("A palette is used to...."), while the other seven were concerned with the history of art ("Rodin's most famous statue is ....").

The Social Studies test has the second highest correlation with VKN. Ten of the 24 items on this scale were concerned with geography, ten with world history, two with American government, and two with economics. On this as on all the 37 information tests the items were multiple choice type with five distractors. The 24th item was:

The United Nations has its headquarters in
A. London.
B. Washington.
C. New York.
D. Paris.
E. Geneva.

The 24-item Literature test comes next in VKN loading. Seven items asked about aspects of American literature, 13 about British literature, and one each about French, Russian, Roman, and Greek literature. The 24th item was:

Heathcliff is a character in
A. Pride and Prejudice.
B. Jane Eyre.
C. Wuthering Heights.
D. Sense and Sensibility.
E. Main Street.

Fourth in VKN loading is Foreign Travel, a five-item test with questions about the English bobby, unexplored jungle, a city with canals, the Thames River (how to pronounce it), and Shinto (where to find it).

Fifth, with a loading of .66 is the 21-item vocabulary test, which asked for meanings of these words:

surrender	barometer	obstruction
lubrication	marinated	concerto
vacuum	solder	placate
retain	discard	ratio
diagram	blunt	source
magnitude	municipal	carnivorous
eccentric	restricted	jalousie

Next comes a 13-item Music scale, which contained questions about topics usually studied in music appreciation lessons. The 13th item was:

Waltz time is
A. 2/4 time.
B. 3/4 time.
C. 4/4 time.
D. 4/8 time.
E. 5/8 time.

The next test in VKN loading is Theater and Ballet, on which six of the eight items asked technical questions about theater and acting, while two concerned ballet, e.g.:

Choreography is found in
A. ballet.
B. sculpture.
C. painting.
D. symphonies.
E. literature.

The ability test with the eighth highest loading on VKN is not an information test, but is the Reading Comprehension test. In this test, the student was given eight passages to read, and after each passage he was asked several questions about what he had read. There were 48 such questions, but the student was told that he probably would not have time to finish the test (time allowed was 30 minutes). The first passage concerned the sloth ("Where do sloths spend most of their lives?"), the second was about the earth's atmosphere, the third was a complaint about the verbosity of tourist guides, the fourth a paragraph on British strategy in the Revolutionary War ("What war is being discussed?"). Then a 16-line nature poem ("What does 'thou' mean in line 13?"), a paragraph on global geology, a short paragraph on discipline in literary writing, and a paragraph about Clive and Hastings in India, one of the questions for which was:

According to the paragraph, Hastings was
A. arrogant and proud.
B. popular among the Indians.
C. a clever and ruthless leader.
D. popular among the British politicians.
E. corrupt.

Next comes the Bible test, which asked 15 questions, nine about the Old Testament and six about the New. The 15th question was:

Which of the following religious proverbs is known as the "Golden Rule"?

A. It is more blessed to give than to receive.
B. An eye for an eye; a tooth for a tooth.
C. Do unto others as you would have them do unto you.
D. Money is the root of all evil.
E. A soft answer turneth away wrath.

The tenth test in importance for the definition of the Verbal Knowledges factor, with a loading of .63, is the ten-item Miscellaneous information test. The aptness of the test name can be seen in the list of item topics: the language of the Romans, citrus fruit, unidentified flying objects, Morse Code for L, science fiction writers, our national anthem, small dogs, Dewey Decimal System, the century of 1002 A.D., and a special ham radio code.

Next comes an 11-item Law scale, the final item of which was:

The term "double jeopardy" refers to

A. retrial after acquittal.
B. fine and imprisonment.
C. confession and conviction.
D. trial without a jury.
E. two defendants.

Then comes a seven-item Military information scale, the final item of which was:

What Navy officer is the same rank as an Air Force First Lieutenant?

A. Lieutenant
B. Lieutenant, junior grade
C. First Lieutenant
D. Second Lieutenant
E. Ensign

Then comes a three-item Journalism scale, with the third item:

In a newspaper, which of these is most likely to be "syndicated"?

A. An advertisement

B. A list of advertisers

C. A circulation list

D. A weather forecast

E. A column

Next comes a nine-item Health test, which asked about allergy, Vitamin C, blood type, carbohydrate, caffein, insulin, milk, plasma, and reviving a carbon monoxide victim.

The 15th test in loading on VKN is Physical Science, with a structure coefficient of .54. The stems of the 18 items were:

1) Atoms combine to form ...
2) In spectrum analysis one uses a ...
3) A lever must have ...
4) An ohm is a unit of ...
5) When a Centigrade thermometer reads 0°, a Fahrenheit thermometer would read ...
6) Which of these is closest to the sun?
7) "Dry ice" is frozen ...
8) Which of these is organic matter?
9) The charge of an electron is considered to ...
10) Which of these is a satellite of the earth?
11) The sun is a ...
12) Which of these is a chemical compound?
13) Sodium chloride is ...
14) Air consists mostly of ...
15) How many stars in the Big Dipper?
16) The mixture of two metals forms ...
17) How fast do radio waves travel?
18) The acceleration due to gravity equals about ...

On this test, as on most of the tests in this list, it is easy to see that the school curriculum provides the primary opportunities to acquire the required knowledge, although other sources of information such as

television certainly contribute to the development of such learnings. Also, for this test as well as for several of the others it is easy to name the specific curriculum units most likely to sponsor the required learnings, in this case physics, chemistry, and general science units. The finding that performances on specific subject-matter tests are to important degrees correlated with a pervasive general knowledge factor, so that this g factor of VKN becomes the best explanatory construct for these many subject-matter tests, makes it evident that specific subject-matter competencies should not be viewed as discrete entities. The traditional subject-matter units which are the building blocks for most curriculum construction are not the appropriate units for a psychological appraisal of the educational attainments of youth. In the first chapter the author argues for a school report card and a school cumulative record that appraise educational progress in terms of independent source traits of schooled performances rather than in terms of a chaotic conglomeration of specific teacher ratings and specific test scores. Such a reform would make it possible for all concerned to understand each student's attainments and potentials far more clearly.

After Physical Science, the next test in VKN importance is a ten-item Accounting scale, the tenth question of which was:

> Things which are temporarily sold below cost to attract customers to a store are called loss
>
> A. seekers.
> B. finders.
> C. gainers.
> D. sellers.
> E. leaders.

Then comes a six-item Architecture test, the final item of which was:

> The Imperial Hotel in Tokyo, which Frank Lloyd Wright designed, is famous for its
>
> A. landscaping.
> B. huge picture windows.
> C. murals.

D. skyscraper design.

E. earthquake-proof construction.

Then comes an 11-item Biological Science quiz, ending with the question:

Which of these is not warm-blooded?

A. Alligator

B. Pig

C. Penguin

D. Hawk

E. Whale

Next comes a ten-item Aeronautics and Space test, the final item of which was:

A space pilot, on blast-off would be subjected to many

A. r's.

B. q's.

C. g's.

D. n's.

E. t's.

The 20th indicator in size of correlation with VKN is a nine-item scale on Outdoor Activities (other than hunting and fishing) that has a loading of .50, so that just one-quarter of the variance on it is explained by the VKN factor. The last item was:

A camper can best insure safe drinking water by

A. straining it.

B. adding iodine.

C. adding penicillin.

D. using lake water.

E. using river water.

Then comes a 14-item Sports test, terminated with the question:

Which of these is a ski turn?

A. Parallel Christie

B. Traverse

C. Herringbone

D. Side step

E. Schuss

Next on VKN loading is a somewhat different test, the ten-item Scientific Attitude test, which confronted the students with alternative explanations or interpretations of unusual situations and required the selection of the most logical or probable of the alternatives. For example:

> Oogroo, a jungle witch doctor, often put a curse on victims which he announced would make these healthy men very ill and weak. This prediction usually came true within a day. The best explanation is that
>
> A. Witch doctors have powers that most people just don't have.
>
> B. The victims believed Oogroo's predictions.
>
> C. The victims faked their illness.
>
> D. Oogroo didn't really have any extraordinary powers, but he thought he did.
>
> E. The victims had failed to guard themselves against the curse.

Then comes a four-item Practical Knowledge test, that inquired about where to get stamps outside post office hours, the meaning of "C.O.D.", the cost of road maps in gas stations, and the shape of a U. S. route number highway sign. Then follows a three-item Photography information scale, followed by a six-item Engineering information scale, the last item of which was:

> A cantilevered roof is one that is supported
>
> A. at one end only.
>
> B. by girders.
>
> C. by an arch.
>
> D. by pillars.
>
> E. from above.

The final ability indicator with its highest loading on VKN is an Electricity and Electronics information scale that correlates .36 with VKN. The last of the 20 items was:

> Electron flow within a radio tube is mostly from the
>
> A. filament to cathode.
>
> B. control grid to cathode.
>
> C. plate to cathode.
>
> D. screen grid to control grid.
>
> E. cathode to plate.

To reiterate, VKN is definitely a g factor, since all 60 abilities tests load positively on it. Only two of the 26 tests we have described as the leading indicators are problem solving tasks of the higher mental processes type, namely Reading Comprehension and Scientific Attitude. The other 24 are straightforward knowledge scales, calling for correct associations between stem and distractor stimuli, or alternatively, correct completion of gestalts initiated by stem stimuli. Long-term memory obviously plays an important role in such performances. Some readers may be disturbed that our most important factor of intellect should be so primitive in its indicators. We remind them that in Chapter One we have embraced Gagné's theory of a hierarchy of learning sets mediating the acquisition of complex skills such as indicate the higher mental processes. In this theory basal knowledges of the VKN indicator type are essential building materials for more impressive intellectual attainments, and are not to be scoffed at in the manner of some progressive educators. Recall that Gagné's paradigm is

Complex Abilities
↑
Basal Knowledges
↑
Differential Aptitudes

VKN is a general source of variance in acquisition and retention of the many subordinate specific knowledges on transfer from which higher level achievements depend. Note that in the paradigm Basal Knowledges are also dependent. We embrace this part of Gagné's theory also, and will propose and test developmental hypotheses implied by Gagné that relate

earlier degrees of differential aptitudes to later degrees of basal knowledges in retest studies of the same subjects over a four-year time span in middle adolescence.

Finally, note that besides the many indicators of differential aptitudes that did not have high loadings on VKN, we also have two sets of knowledge indicators that load only slightly on VKN and that determine two knowledge factors uncorrelated with Verbal Knowledges and with each other, namely English Language and Mathematics. We now consider these two factors which, like VKN, have such obvious curriculum validities that we feel justified in terming the triad VKN, ENG, MAT "Core educational achievement traits."

2. ENGLISH LANGUAGE

Five tests of the English mechanics battery--Spelling, Capitalization, Punctuation, English Usage, Effective Expression--locate the ENG factor, while four other abilities tests have their highest loadings on ENG--Arithmetic Computation, Word Functions in Sentences, Disguised Words, and Arithmetic Reasoning. Table 3.11 reports the ENG correlations and the intercorrelations for these nine scales and for RDG, which loads .39 on ENG.

Each of the 16 items in the Spelling test presented four different words, of which one or none might be mispelled. The last item was:

A. lizzard
B. apparent
C. suppress
D. balloon
E. None of the above

The Capitalization test presented the student with 33 opportunities to decide whether or not to capitalize a word in a completely uncapitalized paragraph. The Punctuation test presented 16 sentences, each missing punctuation in some part, and offered five alternative punctuations for each. The last item was:

Table 3.11

Correlations Among ENG Factor Indicators
(Total R above Diagonal; Pooled Within R below)

Test	SPL	CAP	PNC	USG	EXP	ARC	WDF	DSW	ARR	RDG	ENG
SPL		48	64	54	47	51	52	56	44	56	58
CAP	43		57	52	46	45	37	38	40	48	62
PNC	58	53		65	57	54	65	56	60	67	60
USG	48	48	61		55	44	51	52	51	61	59
EXP	39	41	51	50		39	46	44	47	59	53
ARC	46	41	50	38	32		46	49	50	49	46
WDF	45	32	61	46	40	41		52	58	65	42
DSW	51	34	52	47	39	44	48		48	63	40
ARR	43	39	60	49	44	47	57	45		50	39
RDG	51	44	65	57	53	44	61	59	65		39

Here here dont do that.

A. Here--here, dont

B. Here, here, don't

C. Here, here, dont

D. Here here don't

E. Here, here don't

The 25-item English Usage test consisted of sentences with a missing word or phrase and a set of five alternative ways of completing each sentence, from which the student was instructed to select the best one. The last item was:

The car would run better if it ________tuned up.

A. were

B. was

C. would be

D. is

E. would have been

Each of the 12 items of the Effective Expression test offered a choice among three different ways of expressing an idea. The student was instructed to choose the best. The last item was:

A. We wondered, because for fifteen days Jim had endured hardship and fatigue without complaint, if anything could exasperate him.

B. We wondered whether anything could exasperate Jim, who had endured fifteen days of hardship and fatigue without complaining.

C. For fifteen days Jim had endured hardship and fatigue without complaining, so we wondered if anything could exasperate him.

These five tests locate a factor which any English teacher would recognize as a necessary attainment for young citizens of the United States.

The Arithmetic Computation test has its strongest correlation with the ENG factor (.46), although it also loads on Perceptual Speed and Accuracy (.36). This test allowed the subjects nine minutes to work

72 simple problems in addition, subtraction, multiplication, and division. The 72nd item was:

Divide:

68,931 ÷ 9

A. 6959

B. 8649

C. 7959

D. 7749

E. 7659

The Arithmetic Reasoning test loads .39 on ENG, and also .41 on VKN. This test was composed of 16 items, each of which expressed a quantitative problem verbally. The items required the student to decide <u>how</u> to solve the problems. They did not require him to compute. For example, the first item was:

To find 4 per cent of a number you should

A. multiply by 400

B. multiply by 4.00

C. multiply by .04

D. divide by 400

E. divide by .04

The fact that neither Arithmetic Computation nor Arithmetic Reasoning correlates importantly with the Mathematics factor shows the value of analytic factoring, and should discourage intuitive estimates of factor compositions of tests in lieu of objective estimates. It is just such "surprises" in analytic results that best justify the effort to obtain them. Perhaps we might allude to the computer as an agent of serendipity in such cases.

Word Functions in Sentences is another test which has its major loading on ENG. This test is the first among the abilities indicators for which we have to acknowledge a specific published antecedent, although of course most of the item types employed in the tests we have been describing had occurred previously in published tests. For example, general information items comprised one of the eight subtests

of the Army Alpha test in World War I, and information items were used heavily by Arthur Otis in his later civilian intelligence scales. Similarly, our reading comprehension item-form has been widely used. But the WDF item-form was invented recently by specific psychologists for service in a specific test battery, and Project TALENT is greatly indebted to the authors for permission for the borrowing of the item-form (also to the publisher). The authors, battery title, and publisher are:

> Carroll, J. B. and Sapon, S. M. Psi--Lambda Foreign Language Aptitude Battery. N. Y.: Psychological Corporation, 1955

The WDF item comprises Test 4, Words in Sentences, of the Psi--Lambda Battery. Carroll's item-form is one in which two different sentences are paired. One word is capitalized in the first sentence, and five words are underlined in the second sentence. The subject's task is to decide which of the underlined words has the function in the second sentence of the capitalized word in the first. A sample item was:

BASEBALL is his favorite game.

<u>A</u> <u>pretty</u> <u>girl</u> was walking <u>down</u> the <u>street</u>.
A B C D E

(The answer is C.)

The WDF test contained six sample items, each fully explained, and 24 scored items.

The results of a factor analysis of two foreign language aptitude batteries caused Carroll (1958) to describe this item as a measure of "linguistic interest."

Another test with a meaningful loading on ENG is Disguised Words. (Besides its ENG loading of .40, DSW loads .46 on VKN.) This, too, is an item-form borrowed from the Psi-Lambda Foreign Language Aptitude Battery, in which it comprises Test 3, Spelling Clues Test, although a similar item-form was also used in the Turse Shorthand Aptitude Test (Turse, 1955). In this item-form, the subject is required to decipher words spelled phonetically, and to show his recognition of the disguised

word in the stem by picking a synonym from a list of five distractors. A sample item was:

DLA
A. sadly
B. postpone
C. bluntly
D. hand out
E. everyday
(the answer is B)

There were 30 such items on the DSW test, with the final item:

DPRT
A. recreate
B. depress
C. give away
D. deeper
E. go away

Carroll (1958) suggests that this item-form measures "phonetic-orthographic ability--the ability to form connections between letters and sounds." Carroll first showed the predictive validity of the Psi-Lambda battery for learning a new foreign language in a research in which the criterion variable was course grades of Air Force students in a Mandarin Chinese study course. It will be interesting to see whether the entire ENG factor has special predictive validity for foreign language learnings.

3. MATHEMATICS

Mathematics, the third in our triumvirate of core educational achievement traits, is located by three mathematics tests, although the Physical Sciences information test also has a meaningful loading of .42 on this factor. Table 3.12 reports the intercorrelations among these indicators and their correlations with the MATH factor.

The most related indicator is Advanced Mathematics. This 14-item test contained six algebra items, the last of which was:

Table 3.12

Correlations Among MATH Factor Indicators
(Total R above Diagonal; Pooled Within R below)

Test	MAT	MA9	ADV	PHY	MATH
MAT		78	62	69	62
MA9	77		57	62	61
ADV	56	53		43	71
PHY	67	61	39		42

Which of these equations has <u>no</u> real roots?

A. $X + \sqrt{2} = 1$

B. $X^2 + 16 = 0$

C. $\sqrt{X} = 3$

D. $X^2 - X - 1 = 0$

E. $E.X^2 - X = 0$

There were three geometry questions, and one trigonometry question, which was:

In a triangle with angles A, B, and C, if $\sin^2 A + \sin^2 B = 1$, what conclusion can be drawn?

A. $\sin^2 A + \sin^2 B = \cos^2 C$

B. $\angle A = \angle B$

C. $\angle C = 90°$

D. $(\sin A + \sin B)^2 = 1$

E. $\sin A + \cos A = 1$

There was one question about logarithms, one about simple probability theory. The one question about calculus was:

In calculus, the derivative of $3X^2$ with respect to X equals

A. X^3

B. $9X^4$

C. $9X$

D. $6X$

E. $X^3/3$

The Introductory Mathematics test (MA 9) contained 24 items aimed at testing understanding of basic concepts and methods from ninth grade algebra for the most part, although there were also items on fractions, decimals, percents, intuitive geometry, elementary measurement formulas, and square root. Computation was minimized, and algebra was involved in over 60 per cent of the items. The last item was:

If $X = \frac{4m}{2b + c}$ what does b equal?

A. $\frac{2}{cx - 4m}$

B. $\frac{4m}{2x + c}$

C. $\frac{4m - cx}{2x}$

D. $\frac{2m}{x} - cx$

E. $\frac{2x}{cx - 4m}$

The Mathematics Information test (MAT) consisted of 23 items seeking knowledge of facts and definitions from the subject area of mathematics. For example, the first item was:

Which of these numbers is a perfect square?

A. 3

B. 5

C. 7

D. 9

E. None of the above

The final item was:

Which of these is an irrational number?

A. $\sqrt{2}$

B. .283

C. -3

D. $\sqrt{4.00}$

E. 12/5

Incidentally, MAT correlated .45 with the Verbal Knowledges factor, and MA 9 correlated .39 with VKN, but ADV had no meaningful correlation with the g factor in our system.

In summary, our factor study of 60 separate abilities tests has emerged with three major educational achievement source traits. At

first blush this may appear to be too few constructs to define an adequate core for objectives and appraisal of secondary education. Actually, it would be helpful if educators could be persuaded to concentrate their efforts on the maximization of achievement for each individual student of such a few core learning traits. Teachers of the many different subject areas would discover cohesiveness in the resulting sense of common purpose, and students would realize that the diversity of school subjects and courses only masks the synthetic dimensions of general educational attainment. This factor model enables us to answer clearly and simply the question, "What is education for?" The intellectual heart of elementary and secondary education is maximal attainments for each youth of Verbal Knowledges, English Language, and Mathematics.

Chapter Four

DIFFERENTIAL APTITUDE TRAITS

Aptitudes, in our usage, differ from knowledges and skills in that they are much less influenced by education and training and are much more expressive of innate performance characteristics of individuals. Thus, we do not subscribe to the usage that views achievement traits as aptitudes when they are cast in the role of predictors of future performance. We classify source traits in the abilities domain as aptitudes or achievements according to assumptions or facts about their etiology, not their functions in applied psychology. The hazard in our approach is, of course, that we know so little about the actual origins of source traits and are forced back so quickly on assumptions. Since all traits have some mix of genetic and environmental influences in their etiology, the question posed by our usage is that of ascertaining which factors of intellect are primarily dependent on differences in education and training for their score distributions, and which factors have score distributions that are not heavily influenced by such treatment differences. In a future monograph we will introduce evidence in support of our taxonomy from the Project TALENT retest study and twins study files, but we admit that our terming as differential aptitudes the three factors of Visual Reasoning, Perceptual Speed and Accuracy, and Memory is to some extent a subscription to psychological folklore. We trust that most educators would agree that the triad of VIS, PSA, and MEM factors forms a subset of constructs that is relatively alien to their ordinary language, whereas the triad of VKN, ENG, and MAT factors forms a subset of constructs that is central to their ordinary language. For educational psychologists, at least, our two categories of "core educational achievements" and "differential aptitudes" seem to acknowledge a natural partition of the main abilities domain factors.

In Chapter One we gave as an operational definition of an aptitude that it is a performance set that facilitates speed and precision of

response to a specific, unique class of relatively simple tasks. This definition means that to qualify as an aptitude a factor of abilities must be highly loaded on a small set of indicators that can be accepted as a specific, unique class of relatively simple tasks, and must be negligibly loaded on all other indicators entering the analysis. In other words, the indicators of an aptitude should be both logically and correlationally an obvious subset of the abilities battery. The three aptitude factors in our solution for the 60-test TALENT battery appear to meet this criterion.

I. VISUAL REASONING

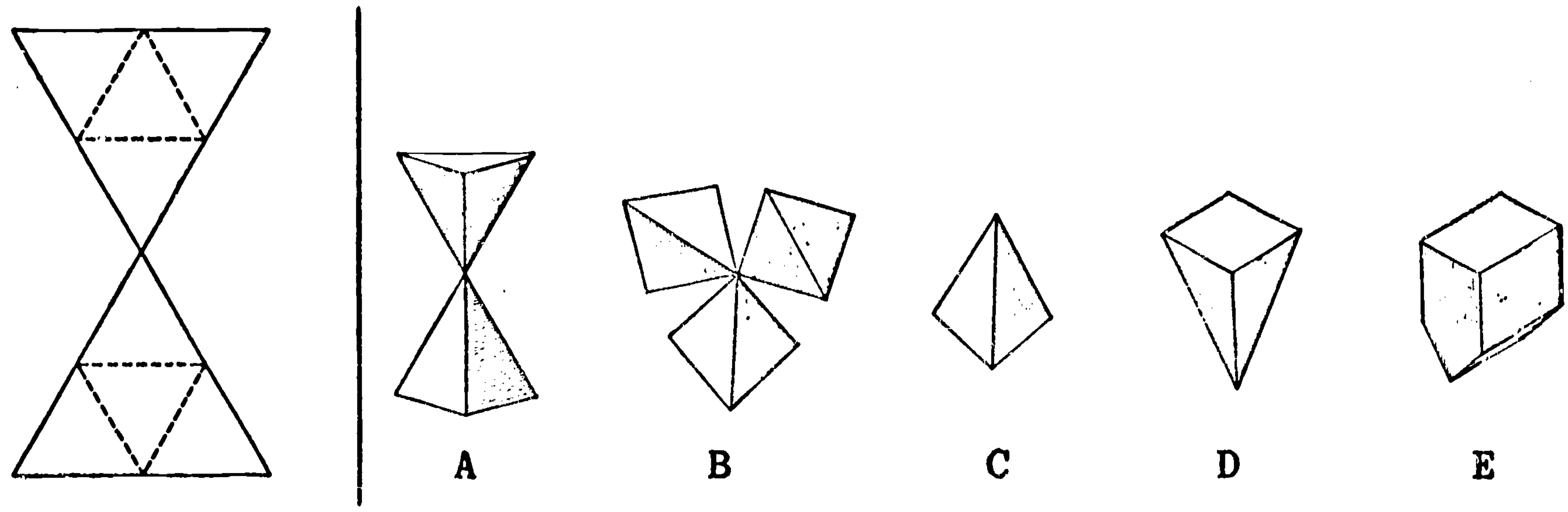
The first of our aptitudes, Visual Reasoning, has long been known to trait and factor psychologists as the nearest rival to g in generality and interest. Often it has been called Spatial ability, because of the prime value of spatial relations tests as indicators of it, but the factor is well-known to be more general than the term spatial connotes, particularly in that mechanical and abstract reasoning tests are good indicators also. The literature on this factor has been organized and enormously enhanced by the recent (1964) publication of I. Macfarlane Smith's book, *Spatial Ability*. Following the description of the Visual Reasoning factor, its commanding relevance for educators will be argued with the borrowed authority of this British expert.

Table 4.1 reports the factor loadings and intercorrelations for the four primary indicators and one interesting correlate of this factor. The key indicator is a test called Visualization in Three Dimensions (VS3). The item-form required the student to visualize what a two-dimensionsal figure would become if it were folded or rolled to form a three-dimensional figure. Folds were indicated by dotted lines and cuts by interior solid lines. The first of the 16 items was:

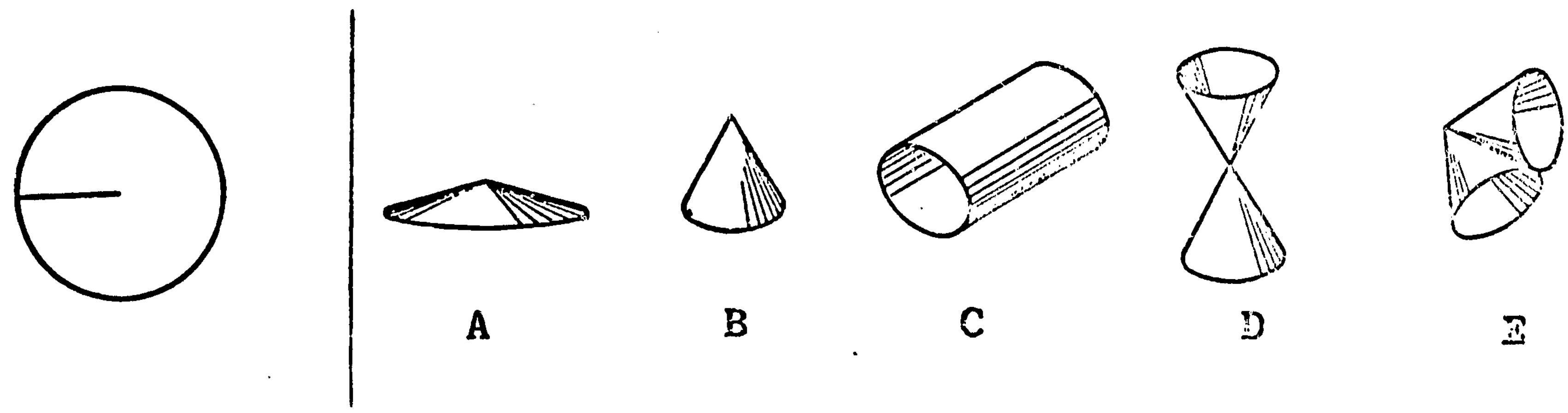
Table 4.1

Correlations Among VIS Factor Indicators
(Total R above Diagonal; Pooled Within R below)

Test	VS3	VS2	MCR	ABS	CRE	VIS
VS3		48	58	55	48	71
VS2	45		50	43	38	63
MCR	56	46		53	52	59
ABS	53	41	55		50	57
CRE	44	35	52	47		41

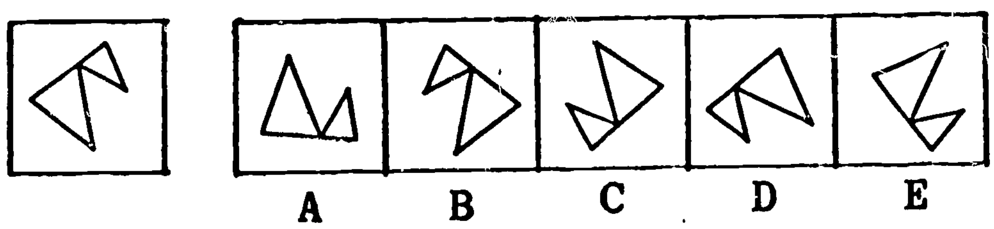


The last item was:

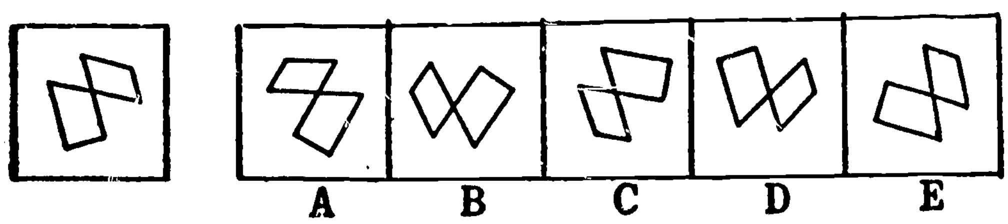


The 24 items of the Visualization in Two Dimensions test (VS2) required the student to judge which one of five figures could be produced simply by rotating in the plane of the page the stem figure. The other four distractors of each item could only be produced by picking the stem figure up and flipping it over, then rotating. The first item was:

Start here:

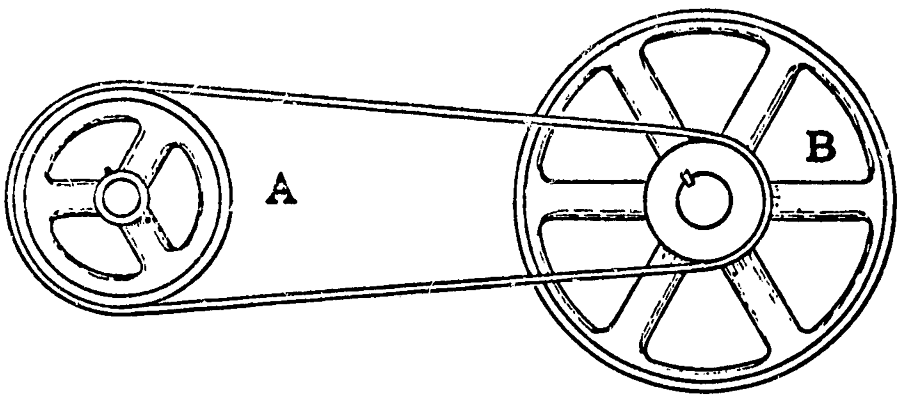


The last item was:



Notice in Table 4.1 the rather low correlations between VS2 and VS3.

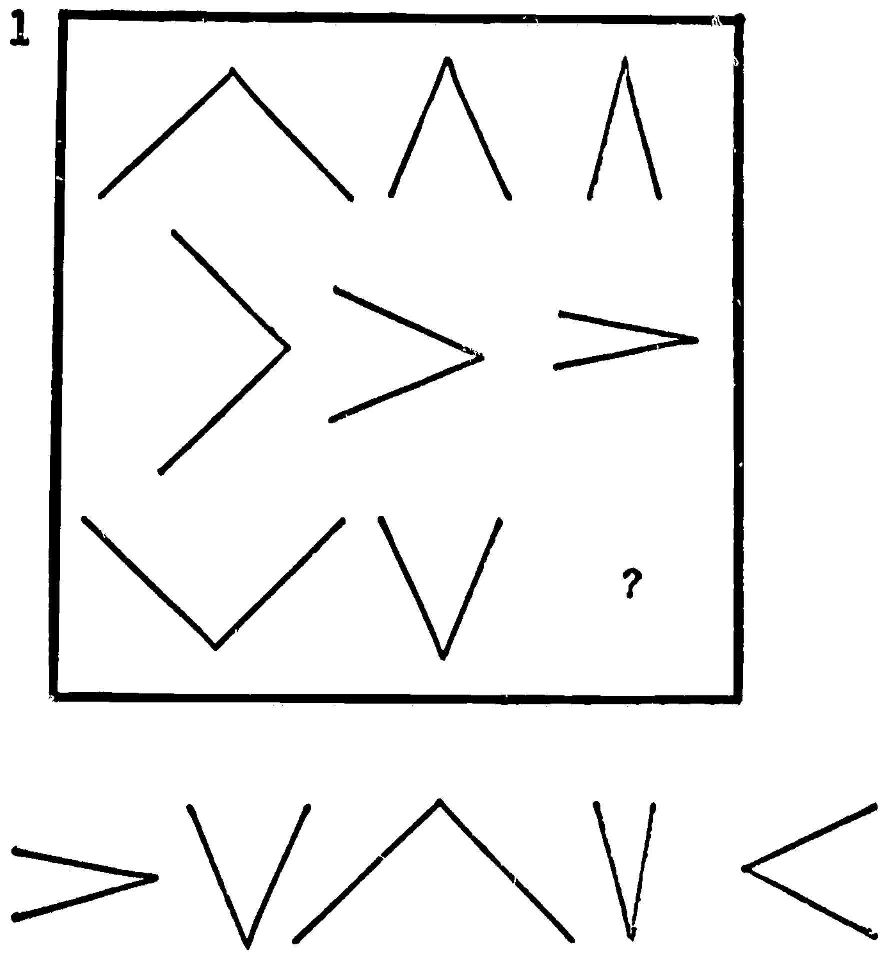
The item-form for the Mechanical Reasoning Test was borrowed from one of G. K. Bennett's (1940) Tests of Mechanical Comprehension. The Project TALENT staff has stated that "the purpose of this test is to measure ability to visualize the effects of everyday physical forces and principles (for example, gravitation, pressure, equilibrium) and the operation of basic kinds of mechanisms (for example, gears, pulleys, wheels, springs, levers)." (Flanagan, 1962, p. 108) The last of 20 items on the MCR test was:



20. Which wheel turns around the greater number of times in a minute?
    - A. A
    - B. B
    - C. The two wheels turn around the same number times in a minute.
    - D. It depends on the direction.

The Abstract Reasoning test (ABS) employed an item-form which has been termed a "pattern matrix." Each item confronted the subject with an incomplete matrix of patterns, and required him to induce from the observable relationships among the patterns present in the matrix what the missing pattern in a specific empty position must be. The first of 15 items was:

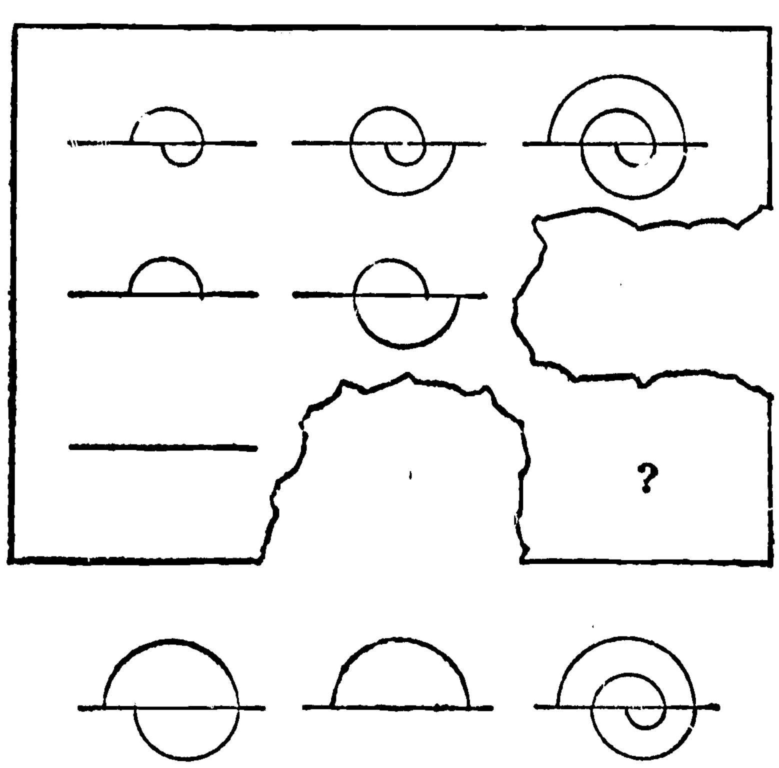
1



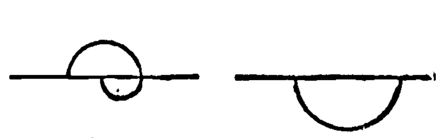
A B C D E

The last item was:

15



A B C



D E

The common denominator in these four tests is rather obviously visual reasoning, hence our name for the factor. This seems to be a better fitting name than Spatial Relations, despite the precedents in the literature.

Probably very few secondary school teachers are aware of the existence of Visual Reasoning as another dimension of intelligence, quite uncorrelated with the Verbal Knowledges dimension. Certainly very little attention has been paid to this dimension in the curriculum and guidance sciences. Should educators be concerned about the Visual Reasoning aptitude scores of the students for whom they plan learning prescriptions? Are there implications of Visual Reasoning scores which students need to be aware of as they plan their educational and vocational careers? I. M. Smith (1964) answers a resounding "Yes!" to these questions, and presents impressive evidence for his positions. He makes two distinct claims for this factor, which he calls spatial ability.

First, according to Smith, spatial ability is a determinant along with _g_ of success in learning mathematics, and spatial becomes increasingly valid as a predictor of math learnings as students penetrate into higher mathematics. In a later monograph we will test this hypothesis against TALENT follow-up data. Smith's explanation of the role of VIS in mathematics learning is that "mathematics is a special kind of 'language,' in which we communicate by means of written signs or symbols ideas which are essentially geometrical or spatial. It is perhaps helpful to think of it as a 'visual' rather than a 'verbal' language." (p. 133) If Smith is correct, educators must appraise youth for visual facility as well as for verbal facility, and must try to direct into mathematics programs those young people with high visual facility. Since the visual and verbal abilities are uncorrelated, students should not be required to be highly successful in literature, language, and social studies to qualify for advanced mathematics training. Of course, neither should high performance in advanced math be required for admission to advanced courses in the verbal disciplines, but this is seldom the case in American education. Verbal types are allowed to shun mathematics

in most of our higher education programs, but usually a student must be very capable in the verbal disciplines to qualify for college at all.

Second, Smith marshals evidence for the proposition that "the best single predictor of success in technical courses is a test of spatial ability, and that the other tests used in the investigations add little to its predictive value." (p. 176) Some of Smith's researches actually turned up small negative beta weights for verbal ability in multiple regression equations for technical course grades. Smith points out that the U. S. Employment Service in its *Estimates of Worker Trait Requirements for 4000 Jobs* (1957) identifies 84 scientific and technical positions as requiring level I (top 10 per cent of population) Spatial ability. Later, we will test this proposition against follow-up data, also.

Smith points out that besides the implication for selection of students for mathematics and scientific or technical courses, there is the further implication for methods of teaching in such courses that a heavy use of visual aids is warranted.

In an endorsing Foreword to Smith's challenging book, P. E. Vernon summarizes the position concisely:

> It would seem that the perception of form is a general characteristic of the abstract thinking involved in mathematics and science, as distinct from the verbal thinking involved in most school subjects. (p. 6)

The correlation of .41 between the Visual Reasoning factor and the Creativity test can perhaps be seen as a concurrent validity of the factor, in line with Smith's thinking. The Creativity test (CRE) employed an item-form invented by J. C. Flanagan for the Ingenuity Test of the Flanagan Aptitude Classification Tests (1958). The item-form required the student to find an ingenious solution to a practical problem, and to indicate his solution in a response format that remained multiple choice yet avoided suggesting the solution. The choices of answers were given in terms of the first and last letters of possible solutions. The first of the 20 items was:

Paralyzed people and others who have to stay in bed for long periods of time often develop bed sores and serious bone diseases due to lying flat so long without being able to stand up. One hospital equipment manufacturer recently developed a new type of bed with electrical controls which permit the patient to move the bed so that he is in an

A.	u - - - - - - t	p - - - - - - n
B.	a - - - - - - g	h - - - - - - t
C.	e - - - - - - r	w - - - - - - d
D.	i - - - - - - c	c - - - - - - g
E.	o - - - - - - f	b - - - - - - t

The correct answer is A, since the solution is "upright position." The only other meaningful factor loading of this test, by the way, was a correlation of .46 with Verbal Knowledges. The author deems the Creativity test as a specimen of a complex mental performance, or higher mental ability in Gagné's hierarchical model, that is mediated by a partnership of two learning sets, one of basal knowledge (VKN) and the other a differential aptitude (VIS).

II. PERCEPTUAL SPEED AND ACCURACY

The Perceptual Speed and Accuracy factor is very clearly compounded from four highly speeded tests. The low intercorrelations among the four indicators, as reported in Table 4.2, probably resulted from low reliabilities of the tests, brought about by widespread discrepancies in the timing of the tests in different schools. Nevertheless the four tests form a subsystem, since their correlations with all other tests except Arithmetic Computation (ARC) were truly negligible. Recall that ARC had its primary loading on English Language. The author deems ARC to be another example of a complex skill mediated by at least two source traits.

The Clerical Checking test (CLR) presented the subject with a list of 74 pairs of names of persons, and required the response of "Same" or

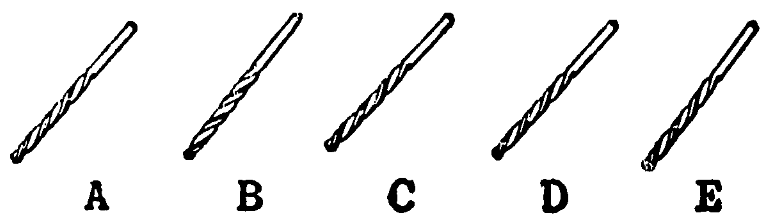
Table 4.2

Correlations Among PSA Factor Indicators
(Total R above Diagonal; Pooled Within R below)

Test	CLR	TBL	OBJ	PRF	ARC	PSA
CLR		47	43	27	31	76
TBL	45		46	23	35	71
OBJ	41	43		21	29	67
PRF	28	24	21		16	56
ARC	27	30	25	17		36

"Different." Working time was supposed to be three minutes. The Table Reading test (TBL) gave the subject three minutes in which to seek answers to 72 questions in a large table titled "Cost of Handkerchiefs of Various Types for Gross Quantities." This table had 20 rows and eight columns of entries. The CLR test was based on a test in the U. S. Employment Service's *General Aptitude Test Battery*, and the TBL test had its origin in a World War II Air Force Aviation Psychology Program "job sample" test for navigators.

The Object Inspection test (OBJ) presented 40 sets of five items in picture form, and required the student to select the one item out of each set that was different from the other four. Again the time limit was three minutes. The 40th item was:



The Preferences tests (PRF) was described by the TALENT staff as "experimental." (Flanagan, 1962, p. 127) It was based on Educational Testing Service's *Social Judgements Test*, and was thought to assess the speed with which an individual can make decisions. The student was confronted with a list of 166 pairs of adjectives and was required to indicate which adjective of each pair he would rather have describe a friend. Working time was again three minutes, and the PRF score was simply the number of choices made in this time period.

The face validity of the PSA factor for certain classes of jobs, such as bank teller or quality control inspector, is obvious. Later we plan to present evidence on the relevance of this aptitude to certain career placements.

III. MEMORY

The third source trait in the aptitudes triad is Memory (MEM). In the TALENT battery there are only two indicators of this factor, Memory for Sentences (MMS) which correlates .83 with the factor, and Memory for

Words (MMW) which correlates .50 with the factor. The Total Sample (both sexes and ninth and twelfth grades) correlation of MMS with MMW is .36, and the Pooled Within Cells correlation is .35. The agreement in these correlations indicates absence of correlated linear model effects for sex and grade. The slight degree of correlation indicates a real difference in the kinds of memory involved in the two tests, and in fact the MMS test measures recall over an elapsed time period (15 minutes) of 40 meaningful sentences, whereas the MMW test measures immediate recall or recognition of English equivalents of essentially meaningless "foreign" language words. Our Memory factor is much closer to the MMS test of delayed recall of meaningful (but not over-learned) material than it is to the MMW test of recognition of meaningless paired associates. This fact probably makes MEM more relevant to the educational setting than it would be if the loadings of MMS and MMW were reversed.

The testing of short-term memory of paired associates has a long history, since it was used in World War I in an effort to measure code learning ability. However, the model for the MMW test of the TALENT battery was provided by Test 5 of the *Psi-Lambda Foreign Language Aptitude Battery*. The item-form asked students to identify the English equivalent of a "Vlaznoor" word from among five distractors, and the 24 items were administered immediately after the students spent two minutes memorizing a 24 pairs list of Vlaznoor-English equivalents. The test allowed four minutes for working the items from memory. The final item was:

ZARN

A. pull
B. moon
C. from
D. tiger
E. upon

Carroll's (1958) factor analysis provided him with support for terming this a test of "associative memory."

IV. SPECIAL KNOWLEDGE FACTORS

To complete the report on adolescent abilities we turn now to nine tests which have their primary or sole meaningful loadings on five minor knowledge factors which are deemed of peripheral significance for educators, although the first three may turn out to be useful predictors in vocational development studies (i.e., Screening, Hunting-Fishing, and Color-Foods). The last two are fairly specific to one information test each, and serve mostly to demonstrate that the first nine factors account for all the group factors (having meaningful loadings on two or more tests) of the domain.

I. SCREENING

The main loading on this factor is .61 for the Screening information test, a 12-item test of extremely simple questions designed to locate functional illiterates and totally uncooperative subjects. Typical of the items were the first and last:

Which of these is made of glass?

A. Tree

B. Mirror

C. Bread

D. Hammer

E. Book

A needle is used in

A. swimming.

B. cooking.

C. reading.

D. sewing.

E. washing.

The Screening test has small positive correlations with the other 69 ability tests. Its correlation with the second indicator of this factor is .38 (pooled within) with Mechanics information, and with the third indicator is .37 (pooled within) with Farming information.

The Mechanics test is a 19-item collection of questions about engines, machinery, and tools that loads .38 on the Screening factor, and has no meaningful loading on any other factor. The first item, quite representative, was:

> Which of these methods is not normally used to join two metal parts?
>
> A. Soldering
> B. Bolting
> C. Riveting
> D. Nailing
> E. Welding

The Farming test loads .47 on Screening, and has an additional loading of .36 on Verbal Knowledges. This test has a pooled-within cells correlation of .53 with the Mechanics test. The 12 items may be represented by the final one:

> Which of these breeds of cattle is black?
> A. Shorthorn
> B. Aberdeen Angus
> C. Brahma
> D. Hereford
> E. Jersey

Chapter Seven discusses sex and grade differences on this and the other special knowledges factors, and later we plan to report some career development validities for these factors.

2. HUNTING-FISHING

The H-F factor is located by a five-item Fishing information test which loads .77. The two indicators correlate .26 with each other. The final Fishing item was:

> A trot line is most often used to catch
> A. perch.
> B. pike.
> C. catfish.

D. bass.

E. trout.

The final Hunting item (of 5) was:

Double action is a term applied to

A. bolt-action rifles.

B. automatic shotguns.

C. automatic pistols.

D. lever-action rifles.

E. revolvers.

3. COLOR, FOODS

The first of the two indicators of this factor is a three-item Colors information test which loads .66, and the second is a four-item Foods test which loads .51, and also has a .46 loading on Verbal Knowledges. The Colors test has a pooled within sex-grade cells correlation of .26 with Foods.

The third Colors item was:

Which of these is <u>not</u> a color?

A. Fuchsia

B. Cerise

C. Taupe

D. Batiste

E. Mauve

The fourth Foods item was:

The main ingredient of vichyssoise is

A. potatoes.

B. cheese.

C. tomatoes.

D. carbonated water.

E. fish.

4. ETIQUETTE

The only indicator of this factor is the Etiquette information test, which loads .71. The second of the two items was:

> In setting a table, which of these usually goes at the left?
>
> A. Teaspoon
> B. Soup spoon
> C. Napkin
> D. Coffee cup
> E. Water glass

5. GAMES

The sole indicator of this factor is a five-item Games test which loads .46, and also loads .41 on Verbal Knowledges. The questions are all about sedentary games, including checkers, chess, and bridge.

6. OTHER TESTS

Finally, there are two of the 60 abilities tests that have not been described yet in Chapters Three and Four because they do not have meaningful loadings on any of the 11 factors described. One of these is a 21-item Home Economics information test, which does have a loading of -.52 on the control factor of Sex, indicating an average superiority of girls over boys on the test. The final item was:

> Which of these should be "packed down" in the measuring cup in following a recipe?
>
> A. Flour
> B. Powdered sugar
> C. Granulated sugar
> D. Bread crumbs
> E. Brown sugar

The second is a three-item Clerical information test, which does have a .53 loading on the control factor of Grade. The third item was:

Where do the typist's initials usually appear on a business letter?

A. Upper left corner
B. Upper right corner
C. Lower left corner
D. Lower right corner
E. Center bottom

Incidentally, the reader should know that the items of the 37 different information test scales were intermixed so that the students were not aware of the many scales themselves, but thought they were taking one general information test, and indeed some research has been conducted with an Information Total score.

The three core educational achievement factors and the three differential aptitude factors provide a parsimonious but powerful set of independent dimensions of intellectual ability, in terms of which a secondary school measurement system could collect and record the most strategic facts about each student's intellectual development. It is in terms of these six factors that the teachers and counselors should "know" their students in the first instance.

Chapter Five

NEED AND INTEREST TRAITS

The factor analysis research on the intercorrelations among 38 typical performance variables yielded a set of 13 uncorrelated source traits, of which two were the control factors of Sex and Grade. This chapter begins with an overview of the factor solution for the motives domain, setting the selected or "official" solution against a background of several alternative solutions. The second part of the chapter describes in detail the indicators for a subset of seven motives called needs: Conformity Needs, Scholasticism, Activity Level, Leadership, Impulsion, Sociability, and Introspection. The third part of the chapter describes the indicators of the other subset of motives called interests: Business, Outdoor and Shop, Cultural, and Science. It also discusses the Sex factor of the motives domain, although the Sex and Grade differences on this typical performance data are treated fully in Chapter Seven.

Three tables convey the overview of the official factor solution for the motives domain. Table 5.1 names the motives factors, and reports their mnemonics and the percentage of the generalized variance extracted by each from the 40 variable total sample correlation matrix (38 scales plus point biserials with Sex and Grade). The factors are listed in their order of importance as explanatory concepts for the correlation matrix. Just as six of the 13 abilities factors were deemed of primary relevance to educational measurement, so six of these motives are judged to be of major importance for a school measurement system, namely CON, SCH, BUS, OUT, CUL, and SCI. This proposition has been amplified in Chapter One. Table 5.2 gives the names, mnemonics, and code numbers of the 38 motives scales of the Project TALENT battery. Those who have read the earlier TALENT monographs will recognize the last 27 scales as the ten Temperament or SAI scales and the 17 Interest Inventory scales, but will be puzzled by the lack of history for the 11 "A" scales. Actually, the first 11 scales named in Table 3.2 were created from

Table 5.1

Motives Domain Factors

Mnemonic	Factor Name	Variance Extracted
CON	Conformity Needs	11.1 %
SEX	Sex	9.1 %
BUS	Business Interests	8.7 %
OUT	Outdoors, Shop Interests	6.8 %
SCH	Scholasticism	6.6 %
CUL	Cultural Interests	5.8 %
SCI	Science Interests	4.3 %
GRD	Grade	4.2 %
ACT	Activity Level	4.0 %
LEA	Leadership	3.1 %
IMP	Impulsion	2.8 %
SOC	Sociability	2.8 %
INT	Introspection	2.4 %

(13 factors extract 71.5% of variance)

Table 5.2

38 Motives Domain Variables

	Mnemonic	Code	Name of Scale
1	MEM	A-001	Memberships
2	LEA	A-002	Leadership Roles
3	HOB	A-003	Hobbies
4	WOR	A-004	Work
5	SOC	A-005	Social
6	REA	A-006	Reading
7	STU	A-007	Studying
8	CUR	A-008	Curriculum
9	COU	A-009	Courses
10	GRA	A-010	Grades
11	GUI	A-011	Guidance
12	NSO	R-601	Sociability
13	NSS	R-602	Social Sensitivity
14	NIM	R-603	Impulsiveness
15	NVI	R-604	Vigor
16	NCA	R-605	Calmness
17	NTI	R-606	Tidiness
18	NCU	R-607	Culture
19	NLE	R-608	Leadership
20	NSC	R-609	Self-confidence
21	NMP	R-610	Mature Personality
22	IPS	P-701	Physical Science, Engineering, Mathematics
23	IBS	P-702	Biological Science, Medicine
24	IPU	P-703	Public Service
25	ILL	P-704	Literary, Linguistic
26	ISS	P-705	Social Service
27	IAR	P-706	Artistic
28	IMU	P-707	Musical
29	ISP	P-708	Sports
30	IHF	P-709	Hunting, Fishing
31	IBM	P-710	Business Management
32	ISA	P-711	Sales
33	ICO	P-712	Computation
34	IOW	P-713	Office Work
35	IMT	P-714	Mechanical, Technical
36	IST	P-715	Skilled Trades
37	IFA	P-716	Farming
38	ILA	P-717	Labor

items in the Student Information Blank specifically for the purposes of this research effort, so they represent new TALENT scales. These "A" scales are based on autobiographical reports of personal activities, in and out of school, whereas the "N" scales of the SAI or Temperament survey represent adjectival self-concepts, and the "I" scales of the Interest Inventory represent professed preferences among vocations and avocations. We will show that these three types of typical performance indicators--activities, self-descriptive adjectives, and interests--prefigure the hierarchical structure of the factor solution. This can be seen in Table 5.3, which reports the meaningful coefficients ($a_{ij} \geq .35$) from the factor pattern and structure matrix, as well as the communalities after 13 factors. (Remember that the point biserial method guaranteed unit communalities for Sex and Grade indicators.)

The salient features of the pattern are first, that an almost general factor of the "N" scales explains most of the intercorrelation among the adjectival self-concepts by means of a social desirability response set. Second, two factors representing independent dimensions of striving explain most of the intercorrelation among the "A" or activities scales. Third, five independent factors account for the intercorrelations among the "I" or interest scales, one of which is SEX. The most noteworthy feature of the hierarchy of factors is the almost complete absence of interlocking relations among the three types of indicators. Each of the seven major factors is defined by indicators drawn exclusively from one subset of scales. The grouping is:

"N", adjectival self-concepts ⟶ Conformity Needs

"A", autobiographical activities ⟶ Scholasticism
Activity Level

"I", inventoried interests ⟶ Business
Outdoor and Shop
Cultural
Science
Sex (control)

Table 5.3

Motives Domain Variable-Factor Correlations $\geq$ .35

Test	CON	SEX	BUS	OUT	SCH	CUL	SCI	GRD	ACT	LEA	IMP	SOC	INT	h^2	R^2
MEM									60					61	31
LEA										83				75	17
HOB									62					68	44
WOR									71					64	29
SOC												62		66	26
REA					39								55	66	25
STU					72									74	52
CUR					70									62	35
COU					53			44						56	40
GRA					75									66	41
GUI					55									54	39
NSO	63											43		68	48
NSS	72													66	56
NIM											87			83	16
NVI	67													61	45
NCA	74													66	52
NTI	75													68	53
NCU	72													70	58
NLE	51									44				61	39
NSC	45												66	76	30
NMP	78													75	64
IPS		47					62							82	77
IBS							74							75	56
IPU			51				37							64	55
ILL			39			68								82	73
ISS		-49	46			35								65	63
IAR						70								70	55
IMU						77								70	44
ISP		35		50										68	50
IHF		50		61										72	58
IBM			74											78	71
ISA			74											68	58
ICO			79											73	62
IOW		-55	62											74	67
IMT		63		51										80	83
IST		35	45	67										84	81
IFA				77										73	55
ILA			45	61										79	68

The fairly tight fit to the data given by the 13 factors reduced rank solution for the total sample correlation matrix is evidenced by Table 5.4, in which the off-diagonal elements of the residual or error matrix, $R_{res} = R - AA'$, are distributed. Finally, comparison of the Guttman lower bounds for the communalities(R^2 column) with the achieved communalities (h^2 column) in Table 5.3 reveals that the achieved h^2 exceeds the multiple correlation of the variable with all the other 39 variables for all indicators except IMT, where the two values are very close. For most indicators h^2 is substantially larger than R^2. It seems evident that enough common factors have been extracted.

Before the data for two sexes and ninth and twelfth grades were pooled, separate factor analyses were conducted for each of the design cells. At this time the number of eigenvalues larger than unity was allowed to dictate the number of factors extracted. Table 5.5 reports the Varimaxed components from each of the samples, arranged for ease of comparison across samples. The four factor patterns are far from identical. The major discrepancy is the appearance of an almost general factor of the Interest Inventory scales in the ninth grade cells, which is subdivided into several more specific interest factors in the twelfth grade cells. Another discrepancy is the appearance in both male cells of an Outdoors and Sports Interests factor that does not appear in the female cells. Nevertheless, the discrepancies are pretty much concentrated in the "I" scales area, and the "A" and "N" scales factors are much the same for all cells, and similar to those of the official total sample solution. Because of the urgent pragmatic arguments for a single solution for all adolescents, the author was inclined to be encouraged by the similarities found in Table 5.5 rather than discouraged by the differences. Chapter Seven will consider the extent to which the control factors of Sex and Grade extracted first in the official solution manage to accomodate some of the difficulties posed by differences in correlation structure among cells of the design.

One alternative to the selected method of passing factors directly through the Sex and Grade indicators would be to rotate a set of principal components of the Total R matrix and allow the Sex and Grade

Table 5.4

Off Diagonal Terms (Upper Triangle) of R-AA′

Lower Limit of Class Interval	Frequency
.00	0
.19	0
.18	0
.17	0
.16	0
.15	0
.14	0
.13	0
.12	0
.11	0
.10	0
.09	1
.08	4
.07	7
.06	7
.05	10
.04	29
.03	27
.02	45
.01	94
-.00	168
-.01	81
-.02	78
-.03	69
-.04	46
-.05	37
-.06	19
-.07	20
-.08	18
-.09	6
-.10	2
-.11	3
-.12	1
-.13	3
-.14	1
-.15	1
-.16	1
-.17	0
-.18	1
-.19	1
-.20	0

N	780
Mean	-.0070
S.D.	.0355

Table 5.5

Varimax Components of 38 Motive Variables
in Separate Sex-Grade Cells

FAI: Conformity Needs

High Loadings (10 SAI Scales)

Sample	Variance	NSO	NSS	NIM	NVI	NCA	NTI	NCU	NLE	NSC	NMP
9 M	5.1	70	77	42	71	78	78	74	58	50	83
12 M	4.7	61	73	22	67	77	76	73	52	52	81
9 F	5.0	66	78	32	66	79	76	77	56	53	81
12 F	4.2	52	72	05	54	78	75	75	47	48	78

FA2: General Interests Level

High Loadings (Int. Inv. Scales)

Sample	Variance	IPS	IBS	IPU	ILL	ISS	IAR	IMU	IBM	ISA	ICO	IOW
9 M	6.4	64	67	74	87	75	70	63	77	70	76	67
9 F	4.2	74	72	59	73	48	62	60	46	34	28	--

FA2B: Business Interests

High Loadings (Int. Inv. Scales)

Sample	Variance	IPU	ISS	IBM	ISA	ICO	IOW	IST
12 M	4.0	64	62	81	79	75	71	30
9 F	3.7	40	49	68	69	75	81	57
12 F	3.1	37	40	71	66	77	73	44

Table 5.5 (continued)

FA2C: Cultural Interests

High Loadings

Sample	Variance	REA	NCU	IBS	ILL	ISS	IAR	IMU
12 M	2.4	31	31	36	69	39	72	78
12 F	3.1	14	27	25	81	46	75	74

FA2S: Science Interests

High Loadings

Sample	Variance	IPS	IBS	COU
12 M	1.9	83	64	36
12 F	2.0	65	61	46

FA3: Mechanics' Interests

High Loadings (Int. Inv. Scales)

Sample	Variance	IMT	IST	IFA	ILA	ISP	IHF
9 M	3.0	66	82	59	78	--	26
12 M	2.8	76	78	50	69	--	31
9 F	3.2	52	55	80	54	62	79
12 F	3.8	70	73	80	65	54	71

FA4: Scholasticism

High Loadings (SIB Scales)

Sample	Variance	SOC	REA	STU	CUR	COU	GRA	GUI
9 M	2.6	41	53	79	62	39	68	54
12 M	3.2	48	49	79	70	66	66	65
9 F	2.6	--	53	79	70	35	67	55
12 F	3.3	57	51	82	77	59	71	65

Table 5.5 (continued)

FA5: Activity Level

High Loadings (SIB Scales)

Sample	Variance	MEM	LEA	HOB	WOR
9 M	2.1	68	54	70	70
12 M	1.9	64	56	67	62
9 F	2.0	63	52	60	67
12 F	2.0	65	60	60	54

FA6: Outdoors and Sports Interests

High Loadings (Int. Inv. Scales)

Sample	Variance	ISP	IHF	IFA
9 M	1.9	65	77	49
12 M	1.9	70	73	62

FA8: Impulsion, Sociability

High Loadings

Sample	Variance	NIM	SOC	NSO	COU
9 M	1.3	58	--	--	49
12 M	1.3	68	50	38	--
9 F	1.3	58	59	40	--
12 F	1.5	70	31	50	--

variables to load on the factors naturally. In order to assure that the main features of the official solution are not artifactual, we need to compare it with this alternative solution. Table 5.6 lists in order of importance the 14 Varimaxed components of the total sample correlation matrix required to bring all the communalities up to or above their Guttman lower bounds (R^2). Every factor of the official solution has its counterpart in this alternative solution, except Sex. The new factor of Office Work in the alternative solution does have a strong Sex loading. The factor pattern for this alternative solution is reported in Table 5.7.

Another alternative solution would result from a decision to factor the pooled within cells or error matrix remaining after the removal of the correlations of linear effects. Eleven Varimax factors of the error matrix are listed in Table 5.8, and the factor pattern for them appears as Table 5.9. All the factors of the official solution have counterparts in this solution, except Introspection. Outdoors Interests and Shop Interests appear as separate factors.

The strong similarities among these alternative solutions, particularly with respect to the major factors, provide evidence that the data rather than the methods have dominated the analyses. In all analyses the three classes of indicators have led to three classes of factors as a result of the rather weak correlational bonds between the indicators of different classes. We might almost as well have factored the A, N, and I subsets of indicators separately. There is no g construct available to hold the indicators of the motives domain in a single family relation as there was for the abilities domain.

II. NEEDS FACTORS

I. CONFORMITY NEEDS

In order to give the adolescent subjects of Project TALENT an opportunity to describe their concepts of themselves, the Student Activities Inventory (SAI) provided 150 statements, each containing an adjectival self description, such as "I am sensitive." One set of

Table 5.6

Alternatives Varimaxed Components of the Motives Domain Total R Matrix

Mnemonic	Factor Name	Variance Extracted
CON	Conformity Needs	11.6 %
OUT	Outdoors and Shop Interests	10.5 %
CUL	Cultural Interests	7.0 %
BUS	Business Interests	6.7 %
SCH	Scholasticism	6.1 %
OFW	Office Work	5.8 %
SCI	Science Interests	4.5 %
ACT	Activity Level	4.4 %
GRD	Grade	4.4 %
LEA	Leadership	2.9 %
SPO	Sports Interests	2.8 %
SOC	Sociability	2.8 %
IMP	Impulsion	2.8 %
INT	Introspection	2.4 %

(14 factors extract 75.7% of variance)

Table 5.7

Motives Domain Variable-Factor Correlations $\geq$ .35

Test	CON	OUT	CUL	BUS	SCH	OFW	SCI	ACT	GRD	LEA	SPO	SOC	IMP	INT	h^2
MEM								69							67
LEA										91					88
HOB								68							72
WOR								68							66
SOC												86			84
REA					43									45	73
STU					78										76
CUR					71										64
COU					38				71						71
GRA					76										68
GUI					43				51						61
NSO	60										38				69
NSS	76														67
NIM													89		86
NVI	62										42				64
NCA	77														67
NTI	80														70
NCU	76														70
NLE	51									42					63
NSC	43													76	83
NMP	82														75
IPS		39					76								88
IBS							78								80
IPU				74											74
ILL			76												83
ISS			51			62									74
IAR			78												73
IMU			78												66
ISP		50									58				72
IHF		66									41				73
IBM				77											82
ISA		35		72											73
ICO				49		60									77
IOW						87									84
IMT		76					38								85
IST		85													85
IFA		80													74
ILA		81													79
SEX		43	-36			-58									83
GRD									85						78

Table 5.8

Alternative Varimaxed Components of the
Pooled Within Sex-Grade Cells R

Mnemonic	Factor Name	Variance Extracted
CON	Conformity Needs	12.3 %
BUS	Business Interests	10.1 %
SCH	Scholasticism	6.9 %
SHP	Shop Interests	6.7 %
CUL	Cultural Interests	6.5 %
OUT	Outdoors Interests	5.2 %
SCI	Science Interests	5.0 %
ACT	Activity Level	4.5 %
SOC	Sociability	3.5 %
LEA	Leadership	3.5 %
IMP	Impulsion	3.1 %

(11 factors extract 67.2% of variance)

Table 5.9

Motives Domain Variable-Factor Correlations $\geq$ .35

Test	CON	BUS	SCH	SHP	CUL	OUT	SCI	ACT	SOC	LEA	IMP	h^2
MEM								58		36		58
LEA										79		69
HOB								66				67
WOR								75				63
SOC									73			65
REA									55			54
STU			66						37			73
CUR			68									58
COU			69									58
GRA			73									61
GUI			59									51
NSO	62											65
NSS	75											63
NIM											82	76
NVI	65											59
NCA	78											63
NTI	78											65
NCU	75											67
NLE	50									47		60
NSC	50									40		62
NMP	81											73
IPS							81					86
IBS							73					73
IPU		56										61
ILL		44			71							81
ISS		58			40							59
IAR					69							66
IMU					78							66
ISP						72						69
IHF						75						70
IBM		77										75
ISA		73										65
ICO		77										72
IOW		75										69
IMT				70			43					80
IST				80								85
ILA		37		77								78
IFA				59		56						71

distractors applied to the entire set of 150 statements:

> Regarding the things I do and the way I do them, this statement describes me
>
> A. extremely well.
> B. quite well.
> C. fairly well.
> D. slightly.
> E. not very well.

Each scored item (42 items were not scored) contributed to the scaling of only one of the ten scales, sometimes called Temperament scales, derived from the SAI. The following sample items suggest the nature of the scales.

Sociability (NSO): "I'd rather be with a group of friends than at home by myself."

Social Sensitivity (NSS): "I never hurt another person's feelings if I can avoid it."

Impulsiveness (NIM): "I like to do things on the spur of the moment."

Vigor (NVI): "I am a fast walker."

Calmness (NCA): "I can usually keep my wits about me even in difficult situations."

Tidiness (NTI): "I have a definite place for all of my things."

Culture (NCU): "I feel that good manners are very necessary for everyone."

Leadership (NLE): "I have held a lot of elected offices."

Self-Confidence (NSC): "I am usually at ease."

Mature Personality (NMP): "When I say I'll do something I get it done."

Table 5.10 reports the intercorrelations of these ten scales. The fact that all the values are positive suggests an important general factor of the scales, and indeed such a factor emerged in the factor analysis. This factor has been termed Conformity Needs because it is judged to be a measure of the extent to which the adolscent subscribes to the middle-class mores of our society. That is, a high score on the factor seems to depend on a willingness of the young person to project a self-concept that is aligned with a stereotype of a solid middle-class American youth. It is noteworthy that Impulsiveness is the only indicator that does not have a meaningful loading on the factor, and it is the only indicator not strongly approved of by middle-class Americans.

At first it may seem to the reader to be unfortunate that a rather primitive and global response set should so dominate the SAI data. The author hopes that reflection will convince the reader that willingness to give at least lip service to the stereotype involved is a very basic requirement for many versions of success in our society, so that a measure of such willingness to conform can be a very useful predictor of educational and vocational placements and adjustments. In any event, if we concede that most of the TALENT subjects have attempted to cooperate with this inventory, it follows that many of our young people recognize the reality of a social stereotype and are willing to subscribe to it in describing themselves. Our follow-up research should be able to establish whether those who do not understand or who reject the stereotype are handicapped in their endeavors in society.

2. SCHOLASTICISM

The Student Information Blank (SIB), containing 394 items, presented the subjects an enormous opportunity to record an objective autobiography. Much of the information collected is about home and family, and is to be related to these personality measures in a later monograph. Another large set of items concerns personal activities in and out of school. Since such behavior patterns express personality traits, the author decided to create some activities indicators from logical clusters of SIB items. Eleven "A" scales were formed out of 108 SIB items. The

Table 5.10

Correlations Among CON Factor Indicators
(Total R Above Diagonal; Pooled Within R Below Diagonal)

Scale	NSO	NSS	NIM	NVI	NCA	NTI	NCU	NLE	NSC	NMP	CON
NSO		52	25	51	43	43	46	37	38	42	63
NSS	50		24	44	58	54	62	41	30	59	72
NIM	25	25		26	16	12	20	27	12	21	26
NVI	51	45	26		43	41	44	41	33	51	67
NCA	42	57	15	43		53	54	39	44	61	74
NTI	41	50	12	41	52		61	34	30	63	75
NCU	44	58	20	45	53	57		42	33	60	72
NLE	36	41	27	41	39	33	42		31	48	51
NSC	38	29	11	32	42	29	32	30		41	45
NMP	40	57	21	51	59	62	59	48	40		78

specific items and the scoring for each A scale will be described under the heading of the factor to which the scale contributes. Five A scales having their only meaningful loadings on Scholasticism are described in this section.

The five indicators which define the SCH factor, in order of importance, are Grades, Studying, Curriculum, Guidance, and Courses. Reading is the only other motive indicator loading meaningfully on the factor. Table 5.11 reports the intercorrelations among these indicators and their factor loadings. As a group, the items of these scales measure the intensity of the student's participation in the academic portion of the school program, as opposed to vocational, recreational, and social parts of the program. The inference is that students with high scores on this factor are more scholastically oriented, in the traditional sense of the word, meaning that they are more interested than their peers in improving their minds *per se*. This interest may result as the natural channeling of high intelligence in our society, or as an expression of belief in a doctrine of mental discipline as sponsored by the Jewish and Catholic faiths, or as a recognition of the success potential of academic achievement, a doctrine enforced by the secular culture. Whatever the etiology, what appears in some adolescents is a need to capitalize on the academic opportunities afforded by the American high school to the fullest extent, and all adolescents can be rated on strength of this need as inferred from self-reported behaviors.

Scholasticism as defined on our data represents a source motive that explains a pattern of school-sited behaviors the society approves and rewards. Chapter Six shows that the strongest tie between abilities and motives is the linkage of Scholasticism to Verbal Knowledges, within the framework of a general relationship of academic orientation and academic achievement. In a later monograph we will describe the familial and neighborhood press antecedents of high Scholasticism, and show some of the predictive validities of this factor for criteria of post-high-school educational and vocational placements. One interesting comparison which is to be made is between Scholasticism and Conformity Needs as prefigurements of "success" in our culture. Another interesting comparison is between this pair of needs and the core educational achievement traits for relative potency in prediction of follow-up outcomes.

Table 5.11

Correlations Among SCH Factor Indicators
(Total R Above Diagonal; Pooled Within R Below Diagonal)

Scale	GRA	STU	CUR	GUI	COU	REA	SCH
GRA		54	42	35	35	23	75
STU	54		50	36	24	36	72
CUR	41	49		34	32	19	70
GUI	33	37	32		45	25	55
COU	34	28	32	36		11	53
REA	24	36	19	31	20		39

The best indicator of Scholasticism is Grades, a scale based on SIB items 106-110, 112, and 113. These items requested the student to report on his usual grades in 1) mathematics, 2) science courses, 3) foreign languages, 4) history and social studies courses, 5) English, 6) business or commercial courses, 7) overall average in all courses starting with the ninth grade. The scoring allotted five points for each A grade down to 0 points for an F grade or no report (subjects were instructed to skip items dealing with areas in which no courses had been taken). Item 111, dealing with grades in vocational courses, was not scored. The result is that students who report themselves as usually earning A grades in all academic courses are awarded the largest increment toward a high SCH factor score.

The second best indicator of SCH is the Studying scale, created from items 65-90 of the SIB, scored to reward the student who reports himself as an industrious and capable student. Table 5.12 reproduces the Studying section of the SIB with the scoring key appended.

Curriculum is another strong indicator of SCH. This scale was scored from SIB item 91, as follows:

91. Which one of the following high school programs or curriculums is most like the one that you are taking? If you have not yet been assigned to a program, which do you expect you will take?

(3 points) A. General--a program that does not necessarily prepare you for college or for work, but in which you take subjects required for graduation and many subjects that you like.

(5 points) B. College Preparatory--a program that gives you the training and credits needed to work toward a regular Bachelor's degree in college.

(4 points) C. Commercial or Business--a program that prepares you to work in an office; for example, as a secretary or bookkeeper.

(2 points) D. Vocational--a program that prepares you to work in a shop or factory, or to enter a trade school, or become an apprentice after high school.

Table 5.12

Studying Scale SIB Items and Scoring Key

Items 65-90. For the following statements indicate how often each one applies to you. Please answer the questions sincerely. Your answers will not affect your grades in any way. Mark one of the following choices for each statement.

A. Almost always
B. Most of the time
C. About half the time
D. Not very often
E. Almost never

A=4	65.	I do a little more than the course requires.
A=0	66.	I have a difficult itme expressing myself in written reports, examinations, and assignments.
A=4	67.	Being a fast reader helps me complete my lessons quickly.
A=4	68.	My grades reflect my ability fairly accurately.
A=4	69.	I make sure that I understand what I am to do before I start an assignment.
A=0	70.	I seem to accomplish very little compared to the amount of time I spend studying.
A=0	71.	Lack of interest in my school work makes it difficult for me to keep my attention on what I am doing.
A=4	72.	I enjoy writing reports or compositions.
A=0	73.	Failure to pay attention in class has caused my marks to be lowered.
A=4	74.	I consider a very difficult assignment a challenge to my abilities.
A=0	75.	I do my assignments so quickly that I don't do my best work.
A=0	76.	I have missed assignments or other important things that the teacher has said, because I was not paying attention.
A=0	77.	My teachers have criticized me for turning in a sloppy assignment.
A=0	78.	Unless I really like a course, I do only enough to get by.

Table 5.12 (continued)

Mark your choices as follows:

A. Almost always
B. Most of the time
C. About half the time
D. Not very often
E. Almost never

A=0	79.	I have difficulty with the mechanics of English composition.
A=0	80.	In class I can't seem to keep my mind on what the teacher is saying.
A=0	81.	I get behind in my school assignments.
A=0	82.	My grades on written examinations or reports have been lowered because of careless errors in spelling, grammar, or punctuation.
A=0	83.	Slow reading holds me back in my school work.
A=0	84.	I pronounce the words to myself as I am reading.
A=0	85.	I feel that I am taking courses that will not help me much in an occupation after I leave school.
A=4	86.	When studying for a test, I am able to pick out important points to learn.
A=0	87.	I don't seem to be able to concentrate on what I read. My mind wanders and many things distract me.
A=4	88.	I keep up to date on my assignments by doing my work every day.
A=0	89.	I have trouble remembering what I read.
A=0	90.	I read material over and over again without really understanding what I have read.

(1 point) E. Agriculture

(0 points) F. A program very different from the above.

Guidance is a SCH indicator based on SIB items 114-129, reproduced in Table 5.13 with the scoring key. The student who has (or claims he has) sought counsel from the most sources on the most topics is awarded the highest increment toward his SCH factor score. Courses is an indicator scaled from SIB items 98, 99, 104, and 105, on which students are awarded points for the number of semesters of course work taken in 1) sciences, 2) foreign languages, 3) algebra, geometry, and trigonometry, 4) calculus. Thus the highest scores go to the students who claim the most preparation in elective college preparatory subjects. A problem with this scale is that it is the only motives indicator with a meaningful loading (.44) on the control factor of Grade. Removal of the grade-related variance has reduced the value of the scale as an indicator of Scholasticism within a given grade to some extent. That is, by Grade 12 this matter of Courses probably is worthy of more emphasis as a Scholasticism indicator than our factoring method allows it to assume.

3. ACTIVITY LEVEL

This factor is defined primarily by Student Information Blank scales indicating Work (loading .71), Hobbies (loading .62), and Memberships (loading .60). The scoring keys for these scales rewarded the subject for both extensivity and intensivity of involvements of these types. Perhaps the most interesting thing about this factor is its uncorrelatedness with the other "A" scale factors of Scholasticism, Leadership, and Sociability. One wonders whether a distinctive future awaits the unusual adolescent who is a high scorer on all four of these autobiographical traits.

The items and their scoring key for the Work scale are reported in Table 5.14, for the Hobbies scale in Table 5.15, and for the Memberships scale in Table 5.16.

Table 5.13

Guidance Scale SIB Items and Scoring Key

Items 114-117. How many times have you discussed each of the following with your teachers or school principal in the past school year? Mark your answers as follows:

A.	None	= 0
B.	One	= 1
C.	Two	= 2
D.	Three	= 3
E.	Four	= 4
F.	Five or more	= 5

114. Colleges or college plans
115. Jobs or occupations after high school
116. Your high school work
117. Personal problems

Items 118-121. How many times have you discussed each of the following with your school counselor in the past school year? Mark your answers as follows:

A.	We have no school counselor.	= 0
B.	None	= 1
C.	One	= 2
D.	Two	= 3
E.	Three	= 4
F.	Four or more	= 5

118. Colleges or college plans
119. Jobs or occupations after high school
120. Your high school work
121. Personal problems

Table 5.13 (continued)

Items 122-129. How many times have you discussed your plans for after high school with each of the following people? Mark your answers as follows:

A.	None	= 0
B.	One	= 1
C.	Two	= 2
D.	Three	= 3
E.	Four	= 4
F.	Five or more	= 5

122. Father
123. Mother
124. Brother or sister
125. School counselor
126. Teachers, principal, or assistant principal (not the school counselor)
127. Clergyman (minister, priest, rabbi, etc.)
128. Friends my own age
129. An adult not listed above

Table 5.14

Work Scale SIB Items and Scoring Key

34. On the average, how many hours a week do you spend doing chores around the house?

A.	None	= 0
B.	One to three	= 1
C.	Four to six	= 2
D.	Seven to nine	= 3
E.	Ten to twelve	= 4
F.	Thirteen or more	= 5

35. How old were you when you first started earning money? *Do not count money earned for doing chores around your own home.*

A.	I have not done this.	= 0
B.	10 or younger	= 5
C.	11 or 12	= 4
D.	13 or 14	= 3
E.	15 or 16	= 2
F.	17 or older	= 1

36. How many summers have you had a regular job for which you were paid? *Do not count money earned for doing chores around your own home.*

A.	None	= 0
B.	One	= 1
C.	Two	= 2
D.	Three	= 3
E.	Four	= 4
F.	Five or more	= 5

37. During the school year, about how many hours a week do you work for pay? *Do not include chores done around your own home.*

A.	None	= 0
B.	About 1-5 hours	= 1
C.	About 6-10 hours	= 2
D.	About 11-15 hours	= 3
E.	About 16-20 hours	= 4
F.	About 21 hours or more	= 5

Table 5.14 (continued)

Items 38-46. How often have you done each of the following kinds of part-time or summer work for pay in the past 3 years? Mark your answers as follows:

A.	Very often	= 4
B.	Often	= 3
C.	Occasionally	= 2
D.	Rarely	= 1
E.	Never	= 0

38. Delivering newspapers, baby-sitting, mowing lawns, house cleaning, etc.
39. Clerical work; typing, filing, etc.
40. Farm work or orchard work
41. Assistant in a science laboratory
42. Factory work
43. Retail store work; stockwork, delivery, clean up, etc.
44. Sales work
45. Camp counselor
46. Other work for pay

Items 47-50. What per cent of your spending money comes from each of these sources? *Choose the closest answer.* Mark your answers as follows:

A.	0 per cent	= 0
B.	20 per cent	= 1
C.	40 per cent	= 2
D.	60 per cent	= 3
E.	80 per cent	= 4
F.	100 per cent	= 5

47. Regular allowance (not scored)
48. From family, as I need it (not scored)
49. From a job
50. Some other source (not scored)

Table 5.15

Hobbies Scale SIB Items and Scoring Key

Items 14-29. How often have you done any one or more of the following in the past 3 years? Include extra-curricular activities at school, but do not include things done for school assignments. In each group of activities, answer for *one* or *more* in the group. Mark your answers as follows:

A. Very often = 4
B. Often = 3
C. Occasionally = 2
D. Rarely = 1
E. Never = 0

14. Drawing, painting, sculpting, or decorating
15. Acting, singing, or dancing for a public performance
16. Collecting stamps, coins, rocks, insects, etc.
17. Building model airplanes, ships, trains, cars, etc.
18. Working with photographic equipment (do not include taking occasional snapshots)
19. Making jewelry, pottery, or leather work
20. Making or repairing electrical or electronic equipment
21. Cabinet making or woodworking
22. Metal working
23. Mechanical or auto repair
24. Raising or caring for animals or pets
25. Sewing, knitting, crocheting, or embroidering
26. Cooking
27. Playing baseball, football, or basketball
28. Gardening, raising flowers or raising vegetables
29. Hunting or fishing

Items 30-33. How often have you done any one or more of the following in the past 3 years? Mark your answers as follows:

A. Very often = 5
B. Often = 4
C. Occasionally = 3
D. Rarely = 2
E. Only once = 1
F. Never = 0

30. Attending concerts, lectures, plays (not motion pictures), ballet; visiting art galleries or museums
31. Playing golf or tennis; swimming
32. Playing hockey, lacrosse, or handball; boxing, wrestling, track, field events
33. Going bicycling, ice skating, skiing, canoeing, horseback riding

Table 5.16

Membership Scale SIB Items and Scoring Keys

Items 1-10. How active have you been in any one or more of the following organizations? Mark your answers as follows:

A.	Extremely active	= 5
B.	Very active	= 4
C.	Fairly active	= 3
D.	A member, but not very active	= 2
E.	A member, but rarely active	= 1
F.	Not a member of any of these organizations	= 0

1. School newspaper, magazine, or annual

2. School subject matter clubs, such as science, mathematics, language, or history clubs

3. Debating, dramatics, o- musical clubs or organizations

4. Hobby clubs, such as photography, model building, hot rod, electronics, woodworking, crafts, etc.

5. Farm youth groups, such as 4-H club, Future Farmers of America, etc.

6. Church, religious, or charitable organization, such as Catholic Youth of America, B'nai B'rith Youth Organization, Protestant youth group; organized nonschool youth groups such as YMCA, YWCA, Hi-Y, Boy's Club, etc.

7. Informal neighborhood group

8. Political club, such as Young Democrats or Republicans

9. Social clubs, fraternities, or sororities

10. Military or drill units

4. LEADERSHIP

Only two scales load meaningfully on this factor. The dominant indicator, with a loading of .83, is the S.I.B. "A" type scale LEA. Table 5.17 reports the three items of the LEA scale. The subject is rewarded for the number of leadership positions he claims to have held in his class, clubs, and teams. The second indicator, with a loading of .44, is the NLE scale of the S.A.I. adjectival self-concept survey, which gave the subject an opportunity to describe himself as a leadership type. Here is a case in which the Varimax procedure paired two different item-form scales, an "A" scale and an "N" scale, which have the same apparent content.

5. IMPULSIVENESS

This is a one-indicator needs factor, located by the adjectival self-concept scale NIM which loads .87 on the factor and gives it its name. The interesting thing about the NIM scale is that it is the only one of the ten "N" type scales that does not load meaningfully on the Conformity Needs factor. Our adolescents seem to recognize that the society does not wish to enforce impulsiveness as a social virtue.

6. SOCIABILITY

This is another two-indicators need factor based on an appropriate pairing of an "A" scale and an "N" scale having the same apparent content. The "A" scale is SOC, with a loading of .62, while the "N" scale is NSO, with a loading of .43. The S.I.B. items and their scoring for the SOC scale are reported in Table 5.18.

7. INTROSPECTION

The motives domain factor of least importance as an explanatory concept is Introspection. This factor was difficult to name because of a lack of similarity of apparent content for the "A" scale, Reading (loading .55), and the "N" scale, Self-Confidence (loading .66). As reported in Table 5.19, the REA scale rewarded the subject who claimed extensive reading outside of school assignments. The author has guessed

Table 5.17

Leadership Scale SIB Items and Scoring Key

11. How many times have you been president of a class, a club, or other organization (other than athletic) in the last 3 years?

A.	None	= 0
B.	Once	= 1
C.	Twice	= 2
D.	Three times	= 3
E.	Four times	= 4
F.	Five or more times	= 5

12. How many times have you been an officer or committee chairman (other than president) of a class, a club, or other organization (other than athletic) in the last 3 years?

A.	None	= 0
B.	Once	= 1
C.	Twice	= 2
D.	Three times	= 3
E.	Four times	= 4
F.	Five or more times	= 5

13. How many times in the last 3 years have you been captain of an athletic team?

A.	None	= 0
B.	Once	= 1
C.	Twice	= 2
D.	Three times	= 3
E.	Four times	= 4
F.	Five or more times	= 5

Table 5.18

Social Scale SIB Items and Scoring Key

51. How old were you when you first went out on a date?

A.	I have never had a date.	= 0
B.	12 or younger	= 5
C.	13 or 14	= 4
D.	15	= 3
E.	16	= 2
F.	17 or older	= 1

52. On the average, how many dates do you have in a week?

A.	I never have dates.	= 0
B.	About 1	= 1
C.	About 2	= 2
D.	About 3	= 3
E.	About 4 or 5	= 4
F.	About 6 or 7	= 5

53. During the school year, on what days are you usually permitted to go out in the evening for fun (until 8 P.M. or later)?

A.	Saturdays only	= 2
B.	Fridays and Saturdays only	= 3
C.	Fridays, Saturdays, and Sundays only	= 4
D.	Any day	= 5
E.	Only for very special occasions	= 1
F.	Never	= 0

54. How many times have you gone "steady" in the past three years?

A.	None	= 0
B.	Once	= 1
C.	Twice	= 2
D.	Three times	= 3
E.	Four times	= 4
F.	Five or more times	= 5

55. On the average, how many evenings a week during the school year do you usually go out for fun and recreation?

A.	Less than one	= 0
B.	One	= 1
C.	Two	= 2
D.	Three	= 3
E.	Four or five	= 4
F.	Six or seven	= 5

Table 5.19

Reading Scale SIB Items and Scoring Key

56. How many books have you read (not including those required for school) in the past 12 months? *Don't count magazines or comic books.*

A.	None	= 0
B.	1 to 5	= 1
C.	6 to 10	= 2
D.	11 to 15	= 3
E.	16 to 20	= 4
F.	21 or more	= 5

Items 57-64. How many books or magazines have you read in each of the following groups (not including those required for school) in the past 12 months? Mark your answers as follows:

A.	None	= 0
B.	1	= 1
C.	2	= 2
D.	3	= 3
E.	4	= 4
F.	5 or more	= 5

57. Western stories, adventure stories, or mystery stories (not comic books)

58. Science fiction books or magazines (not comic books)

59. Science--non-fiction

60. Plays, poetry, essays, literary criticism, or classics

61. Politics, world affairs, biography, autobiography, historical novels

62. Religious books or magazines

63. Comic books

64. Love stories

that the adolescent who is a heavy reader and who needs to be self-confident is likely to be an introspective person.

Of the seven needs factors discussed in this chapter, the two most relevant to an educational measurement system would seem to be Conformity Needs and Scholasticism, because our schools as agents of our society endeavor to sponsor the development of these traits in youth. At least, during childhood and adolescence, in the role of student, these two factors represent the principal social virtues.

III. INTEREST TRAITS

The motives domain source traits discussed so far comprise a set of generalized, unfocussed human needs, representing broad values, goals, or anxieties that form the themes of human lives. In this section we turn our attention to the source traits for a set of highly focussed, specialized needs called interests. An interest is a response set that directs a person's attention toward a specific, unique class of activities. Two types of interests at the surface trait level are vocational interests directed toward specific occupations and work activities, and avocational interests directed toward activities outside the world of work. The distinction between vocational and avocational interests disappears in our source trait solution, however.

In the Project TALENT Interest Inventory the subject was confronted with a list of 205 occupational titles and names of activities and was required to state his degree of liking for each. The instructions and the items of the inventory appear as Table 5.20. Each item has been notated for the scale to which it contributed. There are 17 scales derived from this inventory which comprise the indicators for four factors. Table 5.21 reports the intercorrelations among the 17 surface traits. Table 5.22 names the four factors and lists the indicators having largest loadings for each factor.

The least that can be said for these interest factors is that they are convincing as far as they go. Some readers may regret that the list of interest source traits is not longer to make possible a richer view of the profile of interests of a student. Greater variety in the

Table 5.20

Interest Inventory with Scale Placement of Items
(32 Items not Included in any Scale)

Part I: OCCUPATIONS

Directions: For each occupation listed below you are to consider whether or not you would like that kind of work. *Work quickly. Your first impression is the most valuable. Be sure to answer all of the items. Mark your answers as follows:*

A. I would *like* this *very much*
B. I would *like* this *fairly well*
C. *Indifferent* or *don't know much about it*
D. I would *dislike* this a *little*
E. I would *dislike* this *very much*

ICO	1. Bookkeeper
ICO	2. Bank teller
IBS	3. Surgeon
IPS	4. Chemist
IPS	5. Civil engineer
IBS	6. Dentist
IMT	7. Toolmaker
IMT	8. Automobile mechanic
IST	9. Butcher
IST	10. Tailor or dressmaker
IST	11. Dietitian
ILA	12. Cab driver
ILA	13. Longshoreman
IBM	14. Foreman
	15. Army officer
IBM	16. College president
ISA	17. Insurance agent
ISA	18. Stock salesman
ILL	19. Foreign correspondent
ILL	20. Editor
IMU	21. Musician
	22. Aviator
IFA	23. Rancher
	24. Air line hostess or steward
ISS	25. Social worker
ICO	26. Statistician
IPS	27. Astronomer
IPS	28. Research scientist
IOW	29. Office clerk
	30. Store clerk
IMT	31. Plumber
IMT	32. Electrician
IST	33. Fireman
ILA	34. Dish washer
ILA	35. Maid
	36. Naval officer
IBM	37. Personnel administrator
	38. Credit manager
ILL	39. Lawyer
ILL	40. Reporter
IAR	41. Sculptor
IFA	42. Forester
ISS	43. Elementary school teacher
ISS	44. Nurse
IPS	45. Chemical engineer
IBS	46. Doctor
	47. Pharmacist
IPS	48. Aeronautical engineer
IOW	49. Secretary
IMT	50. Technician
IMT	51. Electronics technician
IST	52. Bricklayer
IST	53. Riveter
IST	54. House painter
	55. Mail carrier
ILA	56. Building superintendent
IBM	57. President of a large company

Table 5.20 (continued)

ILL	58.	Author of a novel
ILL	59.	Librarian
	60.	Economist
	61.	Actor or actress
ISP	62.	Professional athlete
	63.	Policeman
ISS	64.	Clergyman
ICO	65.	Certified Public Accountant
	66.	Spaceman
IBS	67.	Biologist
IPS	68.	Electrical engineer
IPS	69.	Mining engineer
IOW	70.	Typist
IMT	71.	Laboratory technician
IMT	72.	Repairman
IST	73.	Beautician
IST	74.	Railroad brakeman
IST	75.	Shoemaker
ILA	76.	Factory worker
ILA	77.	Deliveryman
ILA	78.	Truck driver
IBM	79.	Building contractor
	80.	Marine Corps officer
ISA	81.	Real estate agent
ILL	82.	Interpreter
ILL	83.	Writer
IMU	84.	Musical composer
IAR	85.	Architect
IAR	86.	Decorator
ISP	87.	Sports umpire or referee
ISS	88.	Guidance counselor
ICO	89.	Accountant or auditor
IPS	90.	Mechanical engineer
IPS	91.	Mathematician
IOW	92.	Switchboard operator
IMT	93.	Machinist
IMT	94.	Welder
IST	95.	Paper hanger
IST	96.	Carpenter
IST	97.	Type setter
	98.	Draftsman
	99.	Housewife
	100.	Air Force officer
IBM	101.	Office manager
IBM	102.	Banker
ISA	103.	Salesman
ILL	104.	College professor
ILL	105.	Poet
IAR	106.	Artist
IAR	107.	Designer
IFA	108.	Farmer
ISS	109.	High school teacher
ISS	110.	Religious worker
ISS	111.	School principal
	112.	Psychologist
IPU	113.	Member of President's cabinet
IPU	114.	Judge
IPU	115.	U. S. Senator
IPU	116.	Politician
IPU	117.	U. S. Congressman
IPU	118.	Mayor
IPU	119.	President of the United States
IPU	120.	Vice President of the United States
IPU	121.	State governor
IPU	122.	Public administrator

Part II: ACTIVITIES

Indicate as in Part I how much you like or would like each of the following:

ISS	123.	Take care of members of family
ICO	124.	Make out income tax returns
IBS	125.	Biology
IPS	126.	Physics
IBS	127.	Study muscles and nerves
IPS	128.	Calculus
IOW	129.	Keep records for a store
IMT	130.	Invent new tools
IST	131.	Fix furniture
IST	132.	Work on an automobile assembly line
ILA	133.	Wash and iron clothes
IBM	134.	Plan work for other people
	135.	Own your own business
ILL	136.	Reading
	137.	Sociology

Table 5.20 (continued)

IHF 138. Fishing
ISP 139. Basketball
ISP 140. Tennis
IFA 141. Raise sheep or cattle for market
ISS 142. Help your parents
ICO 143. Work arithmetic problems
ICO 144. Prepare cost estimates
145. Fortune telling
IOW 146. Typewriting
IMT 147. Make a radio set
IMT 148. Fix a clock
IST 149. Operate a power machine
IBM 150. Fire a person
IBM 151. Manage a large store
152. Save money
153. Work for myself
ILL 154. Write letters
IMU 155. Practice music all day
IAR 156. Art galleries
ISP 157. Football
ISP 158. Track
IFA 159. Operate farm machinery
ICO 160. Operate a calculating machine
IBS 161. Physiology
IPS 162. Chemistry
IPS 163. Play chess
IPS 164. Solve puzzles
IOW 165. Do clerical work
IMT 166. Repair an auto
IST 167. Operate a crane or derrick
ILA 168. Work in a steel mill
IBM 169. Hire a person
IBM 170. Give orders to workers in a factory
171. Buy stocks
ISA 172. Sell furniture
173. Watch TV
174. Act in plays
IHF 175. Trap wild animals
ILL 176. Foreign language
ISS 177. Teach children
ISS 178. Help the poor
ICO 179. Keep accounts
IPS 180. Algebra
IBS 181. Learn about diseases
182. Become a millionaire
ISA 183. Sell merchandise to stores
ILL 184. Literature
ILL 185. Write themes
186. Go to school
IMU 187. Symphony concerts
IHF 188. Hunting
ISP 189. Swimming
IFA 190. Feed hogs and cattle
191. Sell tickets for a railroad or airline
IMT 192. Shop work
IST 193. Do odd jobs with small tools
IBM 194. Direct people
IBM 195. Arrange a strike settlement with management
196. Invest money
ILL 197. Poetry
IMU 198. Play an instrument
199. Studying
IAR 200. Visit museums
201. Exploring
202. Military drill
ISP 203. Baseball
IFA 204. Gardening
IPU 205. Campaign for political office

Table 5.21

Correlations Among Interest Scales
(Total R Above Diagonal; Pooled Within R Below Diagonal)

Scale	IPS	IBS	IPU	ILL	ISS	IAR	IMU	ISP	IHF	IBM	ISA	ICO	IOW	IMT	IST	IFA	ILA
IPS		65	49	29	04	30	20	46	46	46	34	40	-16	69	41	37	33
IBS	68		42	44	33	38	30	35	28	36	26	26	-02	33	22	24	14
IPU	43	40		47	26	31	25	41	30	66	50	39	04	37	33	24	29
ILL	50	49	59		64	67	61	24	06	49	42	38	37	03	15	11	11
ISS	35	44	46	59		44	44	14	-11	36	31	40	56	-12	11	03	09
IAR	46	41	39	65	39		55	24	15	37	33	27	26	13	23	19	13
IMU	35	33	32	59	39	52		16	05	26	23	24	25	04	14	09	09
ISP	36	33	35	37	37	33	25		58	44	34	25	-06	48	43	47	37
IHF	29	26	20	24	18	29	18	50		32	26	09	-24	57	47	64	42
IBM	41	34	64	58	54	43	31	39	24		71	57	25	46	48	31	46
ISA	30	24	48	49	44	37	27	31	20	70		53	28	40	49	30	47
ICO	45	26	40	39	45	27	23	26	11	58	53		53	28	35	15	31
IOW	13	05	23	27	40	18	16	17	05	45	45	63		-17	13	-08	11
IMT	57	34	27	28	26	34	22	36	39	41	37	36	27		76	57	63
IST	30	19	26	28	35	33	23	35	36	44	46	38	41	75		60	81
IFA	25	21	17	23	23	28	17	40	57	25	26	16	13	48	55		54
ILA	20	11	22	23	31	22	18	29	31	42	44	33	38	57	78	48	

Table 5.22

Highest Loadings of Interest Scales

Interest Scales	BUS	OUT	CUL	SCI	SEX	h^2
			Factors			
IPS				62	47	82
IBS				74		75
IPU	51			37		64
ILL	39		68			82
ISS	46		35		-49	65
IAR			70			70
IMU			77			70
ISP		50			35	68
IHF		61			50	72
IBM	74					78
ISA	74					68
ICO	79					73
IOW	62				-55	74
IMT		51			63	80
IST	45	67			35	84
IFA		77				73
ILA	45	61				79

indicators might possibly have resulted in more factors. However, a school measurement system must be fairly simple if it is to be practical, and four uncorrelated dimensions of interest seem to be about the right number for our purpose. The considerable predictive validities for these four interest factors to be documented in a later monograph may reassure some readers of their adequacy as a set of measurement concepts.

If the reader will review the complete motives domain factor pattern as it appears in Table 5.3 he will be reminded that none of the motives factors mixes indicators from the Interest Inventory with indicators from the S.I.B. scales or the S.A.I. scales. This aloofness of the interest scales from the other typical performance measures is quite striking, and dramatizes that the structure of the motives domain is not dominated by a general factor, as is that of the abilities domain. Another striking feature of Table 5.3 is that the important control factor of Sex has meaningful loadings only for interest indicators. The Sex factor is bipolar, as it should be, with interests in social service and office work on the feminine pole and interests in mechanical and technical work, hunting and fishing, and physical sciences at the masculine pole. Chapter Seven explores these sex linkages of interests in detail.

The major issue regarding interest factors in our theory of adolescence concerns the degree to which these factors are dynamic elements of personality. The very definition of an interest as something which directs attention implies a dynamic property, so the issue is not whether interests are dynamic but their relative dynamism in comparison with abilities. The tendency of Project TALENT has been to promote the view that human abilities are more important determinants of criterion behaviors than are interests, and possibly to underestimate the potency of motives in general and of interests in particular. The Project TALENT follow-up, retest, and twins studies provide several ways of comparing abilities and interests as sources of behavior. In the frequently referred to "later monograph" these comparisons will be presented.

Chapter Six

THE STRUCTURE OF ADOLESCENT PERSONALITY

In the Project TALENT data, the surface traits, or indicators, of personality are 60 maximum performance tests and 38 typical performance scales. The source traits, or factors, of personality that have been selected are 11 factors of the tests and 11 factors of the scales. The maximum performance factors have been presented as an explanatory structure for the abilities domain of personality traits, while the typical performance factors have provided an explanatory structure for the motives domain of traits. Technically, each domain structure is a pattern of trait-factor intercorrelations. The pattern explains the interrelationships among the surface traits. From the pattern the matrix of correlations among the traits can be predicted. Symbolically, $\tilde{R} = AA'$.

The 22 source traits are hypothetical constructs in our theory of adolescence. Within each domain the 11 source traits are uncorrelated for any sex-grade population. However, the sources of overt abilities of adolescents and the sources of their usual behaviors should not be uncorrelated. What a person prefers and chooses to do is to some extent dependent on what classes of tasks he is most capable of performing. This is not to deny the reality of social press as the primary source of determination of preferences and activities. Social science has established the special potencies of middle-class mores and lower-class mores in American society. There are also racial, religious, regional, rural, and urban patterns of press that operate powerfully on personality. Furthermore there is reason to credit the potency of a special age pattern called the adolescent culture. Its influence is referred to as peer press. Our research into the influences of these social presses on personality will be reported later. In Chapter Seven we report on systematic sex and grade differences on the source traits. The purpose of this chapter is to report on the structure of the adolescent personality as it is revealed in relationships between the two domains of abilities and motives.

A vital research issue to be considered in the later monograph is the question of whether early abilities influence the development of later motives more than early motives influence the development of later abilities. By late adolescence motives have emerged as an autonomous subsystem of personality. This implies that the motives domain has internal logic, intrinsic dynamics, and is self-sustaining. It influences the development of abilities just as surely as its development is influenced by abilities. However, the theoretical position taken here is that the abilities subsystem has primacy in personality because genetic linkage of individual differences in abilities is stronger and more direct than genetic linkage of differences in motives. This does not contradict the assumption that the etiology and the energy of acquired motives derive from genetically transferred physiological drives. Within a sex group these origins of motives are considered to be fairly evenly distributed. The emphasis in this proposition is on individual differences, not on common elements of inheritance.

The literature of twin studies and family studies from Galton's pioneering efforts to the present day provides ample documentation of the strong and direct genetic linkage of human abilities, as we have pointed out in Chapter One. Trends of similar strength have not been found in twins and families on typical performance traits, although the research on inheritance of motives is sparse and unsatisfactory. A sample of several thousand twin pairs from the Project TALENT data files for which both ability and motive factor measures are available has provided the basis for a thorough inquiry into this issue. A special questionnaire to the twins furnished information from which Dr. Lyle Schoenfeldt, who is conducting these twin studies, was able to estimate zygosity of same-sex twin pairs. Our theoretical position leads us to hypothesize (1) that for all twin pairs, the intraclass correlations of abilities would be higher than the intraclass correlation of motives, and (2) that the intraclass correlations of abilities would increase from fraternal to identical twins to a greater extent than would the intraclass correlations of motives. Thetests that Schoenfeldt's studies provide for our position will be available soon.

The orthogonal factors of the two domains are recapitulated in Table 6.1, with the abbreviations used for them in later tables. The six starred factors in each set are considered to be the most relevant factors to the educational enterprise (assuming that sex and grade are control factors only), and afford a further reduction in dimensionality, in that some of our prediction studies will be based on these 12 factors rather than the full set of 22 factors. As explained in Chapter Two, Section Fourteen, canonical correlation provides the best method of analyzing the correlations between abilities and motives, but the analysis must be based on the pooled within groups correlation matrix of the four sex-grade cells design, since that is the locus of the intradomain orthogonality of factors. Table 6.2 reports this correlation matrix for a sample of 3,100 subjects.

The orthogonality of factors within each domain is nicely borne out by the table. The only departure from theory is the four correlations of Scholasticism with other factors in its domain. As shown in Chapter Seven, this is the only factor that did not have appropriate sample mean and standard deviation. The sample grand mean was too high (.18) and the factor was underdispersed (pooled within S.D. = .77). We simply have a biased sample with respect to this variable. Recall that the indicators for the SCH factor are six scales based on Student Information Blank items, covering reading habits, study habits, curriculum choice, academic courses taken, grades, and use of guidance opportunities in high school. The effort was to place the more academically-oriented student higher on these scales, hence the name "Scholasticism" for the latent trait. This is the most important construct derived from the 11 Student Information Blank scales, and is the only starred motive of Table 6.1 based on actual activities reported by the subjects. The other five starred motive factors differ from SCH in that they all derive from self-reports of preferences, not overt social behaviors. We deem SCH an important factor in our system of constructs, and regret that its distribution properties in this sample, at least, have miscarried.

An interesting simplification of multivariate statistics that occurs when a set of predictor variables is truly orthogonal is that the multiple regression formula

Table 6.1

Factors for Two TALENT Batteries

Code		Mnemonic	Factor Name	Variance Extracted
			ABILITIES DOMAIN FACTORS	
A1	*	VKN	Verbal Knowledges	18.7 %
AG		GRD	Grade	7.8 %
A2	*	ENG	English Language	6.6 %
AS		SEX	Sex	5.7 %
A3	*	VIS	Visual Reasoning	5.3 %
A4	*	MAT	Mathematics	4.1 %
A5	*	PSA	Perceptual Speed and Accuracy	3.6 %
A6		SCR	Screening	3.3 %
A7		H-F	Hunting-Fishing	2.2 %
A8	*	MEM	Memory	2.1 %
A9		COL	Color, Foods	1.9 %
A10		ETI	Etiquette	1.6 %
A11		GAM	Games	1.5 %
			(13 factors extract 64.6% of variance)	
			MOTIVES DOMAIN FACTORS	
M1	*	CON	Conformity Needs	11.1 %
MS		SEX	Sex	9.1 %
M2	*	BUS	Business Interests	8.7 %
M3	*	OUT	Outdoors, Shop Interests	6.8 %
M4	*	SCH	Scholasticism	6.6 %
M5	*	CUL	Cultural Interests	5.8 %
M6	*	SCI	Science Interests	4.3 %
MG		GRD	Grade	4.2 %
M7		ACT	Activity Level	4.0 %
M8		LEA	Leadership	3.1 %
M9		IMP	Impulsion	2.8 %
M10		SOC	Sociability	2.8 %
M11		INT	Introspection	2.4 %
			(13 factors extract 71.5% of variance)	

$$\beta_{c.p} = R_{pp}^{-1} R_{pc}$$

which states that the standardized regression weights, $\beta_{c \cdot p}$, are the product of the inverse of the intercorrelations of the predictors, R_{pp}^{-1}, times the correlations between the predictors and the criterion variable, R_{pc}, simplifies to

$$\beta_{c \cdot p} = I^{-1} R_{pc} = I R_{pc} = R_{pc} \quad .$$

For orthogonal predictors, the predictor-criterion correlations are standardized multiple regression weights, or "beta" weights.

Even though the ability factors are not exactly orthogonal on the sample of 3,100 subjects, we would expect the regression weights for any motive factor on the space of the 11 ability factors to be nearly the same as the corresponding correlations in Table 6.2, and that is what we find. Table 6.3 reports that the six multiple correlations between a motive and 11 ability factors that are equal to or greater than .30 in magnitude. The strongest relationship is .53 between Scholasticism and the abilities, with the highest beta weights on Mathematics, Verbal Knowledges, and English Language. Note, however, that the square of a beta weight gives a better idea of the importance of the predictor in the regression equation, so that ENG does not look like a very useful predictor. It is MAT and VKN that do the work in accounting for about 27 per cent of the variance in SCH. The multiple correlation of Science Interests with the abilities is even more modest with MAT and VKN again doing the work, but accounting for only 18 per cent of the variance in SCI. About 12 per cent of the variance in Conformity Needs is related to variance in abilities, with SCR, PSA, ENG, and VKN the best predictors. Similarly, about 12 per cent of the variance in Cultural Interests is predictable, primarily from VKN, SCR, and GAM, but with high SCR and GAM scores tending to predict low CUL scores. Finally, about 10 per cent of the variance in Outdoors and Shop

Table 6.2

Pooled within Groups Correlation Matrix for Four Cell Design, 3,100 Subjects
(Upper Triangular, Empty Cell Indicates |r|≤.05)

Factors	VKN	ENG	VIS	MAT	PSA	SCR	H-F	MEM	COL	ETI	GAM	CON	BUS	OUT	SCH	CUL	SCI	ACT	LEA	IMP	SOC	INT
VKN	100											13	-16	-08	31	24	27	-20			06	07
ENG		100										13	07		15			-22		-17	06	
VIS			100										-14	14			09		-06	-12		
MAT				100											38	-07	30		10	06	-17	
PSA					100							17	06		07				06	11	09	
SCR						100						18		09	-09	-15						
H-F							100						-06	22	-07	-08			-07			
MEM								100						06								
COL									100						07							
ETI										100		11	06			-06	-07				12	-07
GAM											100			-12	-09	-12				-14	15	
CON												100										
BUS													100									
OUT														100								
SCH															100		19		15		-19	-13
CUL																100						
SCI																	100					
ACT																		100				
LEA																			100			
IMP																				100		
SOC																					100	-06
INT																						100

Table 6.3

Multiple Regressions of Motives on Abilities

Criterion	SCH	SCI	CON
Mult. R	.53	.42	.34
Predictors			
(β)	MAT (.37)	MAT (.30)	SCR (.19)
	VKN (.30)	VKN (.27)	PSA (.18)
	ENG (.15)		ENG (.14)
			VKN (.13)

Criterion	CUL	OUT	ACT
Mult. R	.34	.31	.31
Predictors			
(β)	VKN (.23)	H-F (.21)	ENG(-.22)
	SCR(-.15)	VIS (.14)	VKN(-.20)
	GAM(-.13)	GAM(-.11)	

Interests is predictable, with H-F, VIS, and GAM doing the work, and about 10 per cent of the variance in Activity Level is predictable, with ENG and VKN working in negative roles, so that high ENG and VKN scores tend to accompany low ACT scores.

All in all, there are no surprises here, except perhaps in the low levels of predictability of motives from abilities. The five motives not mentioned in Table 6.3, BUS, LEA, IMP, SOC, and INT, had really negligible predictability. The table lends support to the notion that abilities and motives are relatively autonomous subsystems of personality. Of course, the reader must bear in mind that the systematic influences of sex and grade status have been partialled out of the relationships under study.

Looked at from the viewpoint of regressions of abilities on motives, as in Table 6.4, the interdomain correlations support only three nonnegligible multiple correlations. About 29 per cent of the variance in Verbal Knowledges is predictable from motives variance, with SCH, CUL, and SCI positively related to VKN, and ACT and BUS negatively related. About 22 per cent of the Mathematics variance is predictable, particularly from SCH, SCI, and SOC, with SOC negatively related. Finally, about 13 per cent of English Language variance could be predicted from a combination of motive factor scores, with SCH and CON as positive predictors and ACT and IMP as negative predictors. The noteworthy finding here, beyond the general low level of prediction, is perhaps that high Activity Level scores predict low VKN and ENG scores. Recalling that the indicators for the ACT factor are memberships, hobbies, and work experiences, it is just a little surprising that these behaviors are negatively correlated with two of the key academic achievement factors.

Canonical correlation analysis finds the most correlated linear functions of the two domains. Table 6.5 reports the results of our canonical correlation study. First of all, only four of the possible 11 canonical relations are strong enough to bother discussing, and even these are fairly weak. The strongest relationship is easily interpreted in both domains. It is a correlation of .66 between an academic achievement construct and an academic orientation construct. This is

Table 6.4

Multiple Regression of Abilities on Motives

Criterion	VKN	MAT	ENG
Mult. R	.54	.47	.36
Predictors			
(β)	SCH (.28)	SCH (.30)	ACT(-.22)
	CUL (.23)	SCI (.25)	SCH (.18)
	ACT(-.20)	SOC(-.13)	IMP(-.17)
	SCI (.20)		CON (.12)
	BUS(-.15)		

Table 6.5

Canonical Correlations, F ratios, and Pattern Coefficients
for the Inter-domain Structures
(Coefficients $\leq$ .20 Suppressed)

	$R_c = .66$	$R_c = .45$	$R_c = .39$	$R_c = .34$
	$F^{120}_{\infty} = 35$	$F^{100}_{\infty} = 22$	$F^{80}_{\infty} = 18$	$F^{60}_{\infty} = 15$
Abilities				
VKN	.77			-.36
ENG	.30	-.57		
VIS			-.60	-.24
MAT	.55	.46		.56
PSA				.52
SCR				.25
H-F		.24	-.48	
MEM				
COL				
ETI		-.32		.37
GAM		-.45		
Motives				
CON	.24	-.47	-.27	.38
BUS			.33	.40
OUT		.30	-.56	
SCH	.76			.26
CUL	.26		.46	-.59
SCI	.55	.29	-.29	
ACT	-.34	.37		.29
LEA			.23	.29
IMP		.36	.36	.29
SOC		-.55		
INT				

very convincing, but it is also noteworthy that the overlap in variances of the two constructs is only 47 per cent. We see that academic <u>achievement</u> and academic <u>orientation</u> are related but are not the same. An interesting research would be to inquire into which of these constructs would be the better predictor of teacher-awarded grades.

The second canonical variates are easily interpreted, too. They are both bipolar constructs, with factors on which girls are superior aligned at the better-defined pole, and factors on which boys excel aligned at the other pole. We have a feminine-masculine abilities construct correlated .45 with a feminine-masculine motives construct. The third canonical variates are also sex linked, but with the better-defined pole the masculine one. We have a masculine ability construct correlated .39 with a masculine-feminine motive construct, with CON and IMP operating as suppressor variables. The fourth canonical variates might be viewed as bipolar constructs opposing two kinds of femininity. On the one pole VKN and CUL and on the other pole MAT, PSA and CON, BUS. We have a verbal vs. quantitative ability construct correlated .34 with a cultural orientation vs. business orientation motive construct.

The suggestive sex linkages for the second, third, and fourth pairs of canonical variates are to be tempered with the realization that these constructs apply to all subjects of both sexes and both grades. Since the analysis was based on a pooled within cells correlation matrix, all four sex-grade groups would be located at the same place in the canonical variates space. That is, there would be no sex-grade group differences in means on these variates. The author has hazarded the masculinity-femininity interpretations of canonical constructs in the light of awareness of systematic sex differences on the constituent factors (i.e., that boys as a group are superior on VKN, VIS, MAT, SCR, H-F, GAM and have higher means than girls on OUT, SCI, ACT, IMP, SOC, and INT, while girls as a group are superior on ENG, PSA, MEM, COL, ETI, and have higher means than boys on CON, BUS, SCH, and CUL). These differences are reported and discussed in the next chapter. The sex linkages of the factors, and therefore of any constructs defined from them, are real and interesting, but it certainly is not punitive to observe that a particular girl has a higher MAT score than most boys,

or that a particular boy has a higher CUL score than most girls. These are all measurement traits of adolescence, applying to both sexes, and sex differences on them must be kept in perspective. Later, we will indicate other group variables that are sources of systematic differences on factors.

In summary, the canonical analysis has indicated only very moderate redundancy of the factors of the two domains of personality, validating the notion that abilities and motives are relatively autonomous systems. The most important redundancy is between an academic achievement variate and an academic orientation variate, relating school performance to school motivation.

Chapter Seven

SEX AND GRADE FACTOR DIFFERENCES

Adolescent boys as a group excel over girls as a group at some performance tasks, but do better at others. Most high school teachers would accept this statement, and would be willing to suggest some abilities at which boys as a group seem to be superior. Likewise, distinctive masculine and feminine patterns of interests and activities would be expected. Also, four years of high school ought to produce some systematic development of some abilities and some motives. A very basic objective of Project TALENT has been to clarify and render precise quantitative estimates of sex and grade differences on maximum and typical performance traits of adolescents. Fortunately, as has been explained in Chapter Two, Section Twelve, the point biserial factor research allowed sex and grade differences in surface indicators (the 60 tests and 38 scales) to be reflected naturally as sex and grade differences in source traits (the 11 ability factors and the 11 motive factors).

Table 7.1 reports the means for each sex-grade cell on each of the ability factors, as estimated from a sample of 3,100 subjects (a 20 per cent draw from the total 10 per cent sample of the factor studies, thus a 2 per cent sample of the total TALENT files, reduced through loss of subjects with incomplete score vectors). The scaling of the factors is such that the common within cell standard deviations are unities, so that the entries of Table 7.1 may be viewed as standard score constrasts. Thus the VKN mean of the 12 M cell (twelfth grade males) is almost 2/10 of a standard deviation above the grand mean of zero, while the VKN mean of the 12 F (twelfth grade females) cell is just 2/10 of a standard deviation below the grand mean. In the following discussion, differences of 1/10 of a standard deviation (1/10 S) or more will be treated as meaningful, while differences of less than 1/10 S will be treated as negligible.

Looking first at sex difference in abilities, we see some pronounced contrasts. Males outperformed females by over 4/10 S on Verbal Knowledges.

Table 7.1

Ability Factor Contrasts for Four Design Cells

Factor	Cell Means 12 M	9 M	9 F	12 F
Verbal Knowledges	.19	.34	- .20	- .20
English Language	-1.04	- .88	1.04	.95
Visual Reasoning	.64	.55	- .59	- .72
Mathematics	.99	.65	- .63	- .95
Perceptual Speed and Accuracy	- .19	- .05	.22	.07
Screening	.28	.21	- .22	- .33
Hunting-Fishing	1.19	1.01	-1.04	-1.27
Memory	- .58	- .50	.57	.55
Color, Foods	-1.09	- .79	.83	1.11
Etiquette	- .67	- .49	.57	.62
Games	.41	.26	- .19	- .31

Of course, the educational significance of this finding depends on the opinion the reader has of the comprehensiveness and balance of the sample of indicators. That performances of the sex groups on the indicators foreshadowed the male superiority on the factor can be seen in the following lists of indicators with loadings ≥ .35 on which each sex excelled. The asterisks identify indicators with loadings ≥ .60.

Males Superior	Females Superior
* Vocabulary	* Music
* Literature	Scientific Attitude
* Social Studies	* Art
Mathematics Information	Health
Physical Sciences	Journalism
Biological Sciences	Accounting
Aeronautics and Space	Practical Knowledge
Electricity and Electronics	* Bible
Farming	Photography
Sports	* Theater and Ballet
* Law	Foods
Engineering	Disguised Words
Architecture	Punctuation
* Foreign Travel	English Usage
Military	Word Functions
Outdoor Activities	* Reading Comprehension
Games	
* Miscellaneous	
Creativity	
* Arithmetic Reasoning	
Introductory Mathematics	

Males were superior on five more scales than were females, and on one more high-loaded scale. The surprises are perhaps the male superiority on Vocabulary and Literature and the female superiority on Scientific Attitude. However, both the Literature and Scientific Attitude differences are quite negligible. In fact, most of the point biserial

correlations of indicators with sex are very slight, as reported in Table 7.4, although there are some substantial relations. The reader is urged to consider the details of Tables 7.4 and 7.5 as he evaluates the entire discussion of sex and grade differences, because the point biserials of indicators with sex and grade are the origins of the factor differences.

Girls as a group were superior on the English Language ability factor by a substantial margin of approximately 2 S. This is one of the strongest contrasts in the data. The following lists make it clear that females were higher performers on most of the indicators of the ENG factor:

Males Superior	Females Superior
Arithmetic Reasoning	Disguised Words
Introductory Mathematics	Spelling
	* Capitalization
	* Punctuation
	English Usage
	Effective Expression
	Word Functions
	Reading Comprehension
	Arithmetic Computation

Boys were superior by about 1.2 S on Visual Reasoning, and were superior on all five indicators of the factor:

Creativity
Mechanical Reasoning
* Visualization in Two Dimensions
* Visualization in Three Dimensions
Abstract Reasoning

Boys were also superior on Mathematics, by about 1.5 S, and again were superior on all four indicators:

* Mathematics Information
  Physical Sciences
* Introductory Mathematics
* Advanced Mathematics

Girls outperformed boys by almost 3/10 S on Perceptual Speed and Accuracy, with the following outcomes on the significant indicators:

Males Superior	Females Superior
Preferences	Arithmetic Computation
	* Table Reading
	* Clerical Inspection
	* Object Inspection

Boys had the higher mean on the Screening factor, with a difference of about 1/2 S between boys and girls, although girls were a little above boys on the primary indicator:

Mechanics	* Screening
Farming	
Preferences	

Boys were strongly superior on the Hunting-Fishing factor, by about 2 S, and were superior on both indicators, Hunting Information and Fishing Information.

Girls were about one standard deviation superior on the Memory factor, and were superior on both memory tests. The females also excelled by 2 S on the Color, Foods factor, and on both constituent information tests. They also excelled by about 1 S on the Etiquette factor and test. Finally, boys excelled by 1/2 S on the Games factor, and on the corresponding test.

From the point of view of our argument in Chapter Four, three of the ability factors may be construed as general aptitudes, while the others are seen as knowledge or achelvement traits. In this view, boys

excelled on one of the aptitudes, Visual Reasoning, while girls excelled on two aptitudes, Perceptual Speed and Accuracy, and Memory. Presumably there are vocations requiring special capacity in one of these aptitudes for which these sex differences are relevant, although we must remember that there is ample opportunity for a particular member of one sex to excel in an aptitude on which the group performance of the other sex is superior. Three of the eight knowledge factors represent core achievement variables in any appraisal of academic education in the United States. Boys excelled on two of these, Verbal Knowledges and Mathematics, while girls excelled on the other, English Language. On the remaining less important knowledges, sex differences were in line with customary views of sex roles.

Turning our attention to grade differences in Table 7.1, we see little that should be encouraging to educators. On two of the core educational achievement factors, Verbal Knowledges and English Language, there is no meaningful change. There is a small (3/10 S) positive change in Mathematics for boys, but it is offset by a decline of the same magnitude in Mathematics for girls. This analysis of the Project TALENT data projects a dim, almost dismal, picture of the overall academic impact of the American high school. Later we will show that selected groups of students do show more gain on these factors for four years of education.

Grade differences on the three aptitude factors are not large enough to be meaningful. On the remaining five knowledge factors, only the improvement in girls' Color, Foods mean scores from ninth to twelfth grades seems to be noteworthy.

Table 7.2 displays the sex and grade contrasts for the 11 motive factors, and Table 7.5 displays the point biserial correlations with sex and grade for the 38 indicators. The motives factor pattern can be reviewed in Chapter Five, Table 5.3. On four of the motive factors the male means were substantially higher than the female means, so that they may be viewed as a set of masculine motives. They are:

Table 7.2

Motive Factor Contrasts for Four Design Cells

Factor	Cell Means 12 M	9 M	9 F	12 F
Conformity Needs	- .45	- .44	.49	.41
Business Interests	- .21	- .21	.29	.16
Outdoor, Shop Interests	1.33	1.33	-1.36	-1.26
Scholasticism	.06	.17	.25	.22
Cultural Interests	-1.15	-1.11	1.03	1.17
Science Interests	1.16	1.13	-1.16	-1.10
Activity Level	.22	.23	- .33	- .29
Leadership	- .05	.04	- .06	- .02
Impulsion	.39	.31	- .32	- .42
Sociability	.18	.15	- .05	- .03
Introspection	.21	.14	- .11	- .16

Outdoor, Shop Interests	(2-1/2 S)
Science Interests	(2-1/4 S)
Impulsion	(3/4 S)
Activity Level	(1/2 S)

On three of the motive factors the female means were substantially higher than the male means, so that they may be viewed as a set of feminine motives. They are:

Cultural Interests	(2-1/4 S)
Conformity Needs	(9/10 S)
Business Interests	(4/10 S)

The essentially sex neutral motive factors are:

Scholasticism
Leadership
Sociability
Introspection

The terminology of "masculine" and "feminine" motives will help us to remember the meaningful sex differences on the factors, but it is absolutely necessary to recognize that these are not punitive categories when applied to members of the opposite sex. Rather, these are all traits that are measurable and meaningful personality attributes for both sexes.

All that needs to be said about grade differences on motive factors is that there are none of importance.

Table 7.3 reports the separate within cell standard deviations for the factors of both domains, which by hypothesis differ from unity only by chance. The pooled within cells standard deviations can be seen in Table 7.8 to be very close to unity. Table 7.3 also reports the total sample standard deviations, which reflect the over-dispersion in total sample distributions due to real differences in subsample means.

Total sample correlations due to correlations among cell means are reported in Table 7.6. In Chapter Two, Section Thirteen, it has been shown that within each domain of factors these correlations are in fact due to the cell means, as they can be generated from the means. The

Table 7.3

Cell Standard Deviations, Total Sample Means and Standard Deviations for 22 Factors on 2% Sample

Factor	Design Cells S.D.				Total Sample	
	12 M	9 M	9 F	12 F	Mean	S.D.
Abilities						
VKN	1.07	1.03	.92	1.00	.04	1.03
ENG	.95	1.04	.98	.95	.02	1.39
VIS	1.21	1.03	.91	1.07	-.03	1.22
MAT	1.42	.75	.69	1.12	.01	1.29
PSA	1.09	.97	.94	.95	.02	.99
SCR	.95	1.11	.94	.86	-.01	1.01
H-F	1.25	1.08	.79	.86	-.03	1.50
MEM	1.01	.94	1.01	1.10	.01	1.15
COL	1.05	.90	1.00	1.05	.02	1.37
ETI	1.01	.98	1.00	.98	.01	1.15
GAM	.98	1.02	.96	.97	.04	1.03
Motives						
CON	1.01	.99	1.00	.98	.00	1.09
BUS	1.00	1.01	.94	1.03	.01	1.02
OUT	1.09	1.04	.96	1.00	.01	1.67
SCH	.83	.73	.70	.82	.18	.77
CUL	1.04	.88	.97	1.12	-.02	1.49
SCI	1.08	.97	.86	1.00	.00	1.50
ACT	.99	1.12	.97	.86	-.04	1.03
LEA	1.03	.98	.94	1.02	-.02	.99
IMP	1.07	.98	1.02	1.02	-.01	1.08
SOC	1.01	1.03	.97	.92	.06	.99
INT	.98	.94	.97	1.01	.02	.99

Table 7.4

Point Biserial Correlations between Abilities Indicators and Sex and Grade Dichotomies (Positive where Males or 12th Grade had Higher Mean)

Indicator	Sex	Grade
Screening	-.13	.18
Vocabulary	.13	.34
Literature	.01	.42
Music	-.10	.26
Social Studies	.15	.30
Mathematics Information	.18	.30
Physical Sciences	.27	.11
Biological Sciences	.18	.27
Scientific Attitude	-.01	.30
Aeronautics and Space	.42	.12
Electricity and Electronics	.44	.16
Mechanics	.52	.27
Farming	.13	.23
Home Economics	-.52	.27
Sports	.39	.24
Art	-.05	.24
Law	.14	.35
Health	-.11	.30
Engineering	.22	.24
Architecture	.00	.21
Journalism	-.01	.31
Foreign Travel	.16	.20
Military	.21	.25
Accounting	-.00	.39
Practical Knowledge	-.04	.28
Clerical	-.20	.53
Bible	-.03	.20
Colors	-.25	.18
Etiquette	-.18	.15
Hunting	.43	.13
Fishing	.30	.10
Outdoor Activities (other)	.15	.21
Photography	-.03	.23
Games (sedentary)	.18	.09
Theater and Ballet	-.16	.31
Foods	-.13	.21
Miscellaneous Information	.08	.21
Memory for Sentences	-.12	.02
Memory for Words	-.17	.19
Disguised Words	-.11	.27
Spelling	-.25	.33
Capitalization	-.16	.20
Punctuation	-.21	.28
English Usage	-.16	.28
Effective Expression	-.15	.32
Word Functions in Sentences	-.14	.26
Reading Comprehension	-.06	.35
Creativity	.08	.28
Mechanical Reasoning	.44	.17
Visualization in Two Dimensions	.18	.13
Visualization in Three Dimensions	.14	.21
Abstract Reasoning	.03	.21
Arithmetic Reasoning	.08	.28
Introductory Mathematics	.09	.21
Advanced Mathematics	.14	.33
Arithmetic Computation	-.11	.28
Table Reading	-.03	.25
Clerical Checking	-.11	.19
Object Inspection	-.06	.19
Preferences	.02	.00

Table 7.5

Point Biserial Correlations Between Motives Indicators
and Sex and Grade Dichotomies
(Positive where Males or 12th Grade had Higher Mean)

Indicator	Sex	Grade
Memberships	-.03	.03
Leadership Roles	-.09	-.02
Hobbies	.24	-.13
Work	.28	.12
Social	.01	.20
Reading	-.13	-.11
Studying	-.19	.05
Curriculum	-.10	.11
Courses	.13	.44
Grades	-.08	.13
Guidance	-.03	.34
Sociability	-.15	.10
Social Sensitivity	-.24	.18
Impulsiveness	.01	.04
Vigor	.00	.07
Calmness	-.07	.20
Tidiness	-.21	.14
Culture	-.25	.16
Leadership	-.04	.06
Self-Confidence	-.02	.13
Mature Personality	-.10	.19
Physical Science, Engineering, Mathematics	.47	.03
Biological Science, Medicine	.11	.06
Public Service	.26	.03
Literary, Linguistic	-.28	.09
Social Service	-.49	.08
Artistic	-.21	.13
Musical	-.21	.08
Sports	.35	.04
Hunting, Fishing	.50	.02
Business Management	.22	.11
Sales	.17	.09
Computation	-.00	.12
Office Work	-.55	.04
Mechanical, Technical	.63	.06
Skilled Trades	.35	.04
Farming	.34	.03
Labor	.34	.02

Table 7.6

Total Sample Correlation Matrix for 22 Factors, 3100 Subjects of the 2% Sample
(Correlations of Cell Means)

Factors	ENG	VIS	MAT	PSA	SCR	H-F	MEM	COL	ETI	GAM	CON	BUS	OUT	SCH	CUL	SCI	ACT	LEA	IMP	SOC	INT
VKN	-16	10	15	-01	04	14	-12	-13	-11	05	02	-20	13	29	-02	34	-13	05	11	08	10
ENG		-35	-43	10	-20	-54	32	47	35	-20	37	20	-58	16	54	-54	-34	00	-34	-03	-14
VIS			31	-07	12	38	-22	-34	-26	12	-19	-23	48	-02	-40	44	14	-05	07	02	08
MAT				-07	16	45	-28	-42	-32	17	-24	-14	48	24	-50	62	14	08	25	-07	07
PSA					-05	-09	03	11	03	-04	21	09	-12	08	09	-09	00	06	06	08	01
SCR						19	-11	-17	-11	03	06	-10	25	-11	-28	20	04	-03	04	05	05
H-F							-35	-51	-38	19	-32	-20	68	-10	-59	58	22	-03	27	09	15
MEM								32	21	-12	24	11	-34	07	36	-35	-15	01	-17	-05	-05
COL									35	-17	31	11	-53	11	53	-53	-15	00	-21	-06	-12
ETI										-13	29	16	-41	04	34	-42	-12	03	-16	05	-14
GAM											-09	-04	15	-11	-28	23	03	-03	-03	17	01
CON												09	-32	07	30	-33	-11	00	-14	-02	-04
BUS													-17	-03	16	-18	-08	-01	-09	-01	-06
OUT														-08	-60	60	21	02	27	07	11
SCH															08	07	-03	15	02	-20	-14
CUL																-56	-19	-03	-24	-06	-11
SCI																	19	01	26	11	15
ACT																		00	09	05	06
LEA																			00	03	01
IMP																				05	06
SOC																					-04
INT																					

presence of some rather large entries in Table 7.6 suggests the possibility of extracting some factors explanatory of the relations among subsample means. Actual computation indicated that only one substantial factor was present, the pattern coefficients for which are reported in Table 7.7. The factor is clearly bipolar with the abilities and motives on which males as a group were superior at one pole and those source traits on which females excelled at the other pole. An interesting analytic outcome was observed when a four-cell discriminant analysis was run on the 22 factors, because the first (and only meaningful) discriminant function turned out to be exactly the first principal component of the total sample correlation matrix (compare Table 7.7 and the discriminant pattern coefficients of Table 7.8). This identity provides the final demonstration that the total sample factor correlations within each domain are solely functions of design cell means. Also, the means for the four sex-grade cells on this first discriminant function, as reported in Table 7.9, make it very clear that the separation obtained is primarily between the two male cells on the one hand and the two female cells on the other hand. It is noteworthy that the twelfth grade males-females divergence is the extreme contrast in the table.

In summary, the generalizations suggested by the data on sex and grade differences in the factor space are:

1. sex differences on factors of abilities and motives are for the most part important in magnitudes and meaningful in directions, while grade differences are for the most part too small to be of theoretical significance;
2. there is a fairly consistent tendency for sex differences to be more extreme in the twelfth grade than they were in the ninth grade.

The author concludes that sex is an important theoretical variable in adolescence and should be used as a construct in all educational research on adolescents, while grade may often be ignored as a theoretical influence on adolescent personality, provided that routine statistical control of grade variance is incorporated in research designs.

Table 7.7

First Principal Component of Total Sample Correlation Matrix (Correlations of Cell Means)

$\lambda = 5.73$; 26% of trace

Pattern Coefficients

Abilities		Motives	
VKN	.23	CON	-.47
ENG	-.76	BUS	-.29
VIS	.56	OUT	.81
MAT	.67	SCH	-.07
PSA	-.15	CUL	-.77
SCR	.29	SCI	.81
H-F	.78	ACT	.30
MEM	-.50	LEA	.00
COL	-.70	IMP	.37
ETI	-.55	SOC	.09
GAM	.29	INT	.19

Table 7.8

Four Design Cells Discriminant Pattern Coefficients, Univariate F Ratios, and Pooled within Groups Standard Deviations

(for first discrim: R_c=.94; 99% of trace of $W^{-1}A$;
26% of trace of total R extracted; Λ=.10)

Factors	Pattern	F^{3}_{4000}	Within S.D.
VKN	.24	61	1.00
ENG	-.75	1016	.99
VIS	.54	361	1.05
MAT	.66	562	1.00
PSA	-.14	23	.98
SCR	.27	71	.98
H-F	.79	1287	1.00
MEM	-.50	303	1.01
COL	-.73	936	.99
ETI	-.54	357	.99
GAM	.30	91	.98
CON	-.44	211	.99
BUS	-.23	52	1.00
OUT	.84	1737	1.02
SCH	-.08	9	.77
CUL	-.79	1280	1.00
SCI	.81	1416	.97
ACT	.28	79	.99
LEA	.02	2	.99
IMP	.35	126	1.02
SOC	.11	11	.99
INT	.17	26	.97

Table 7.9
Means for Four Design Cells on
First Discriminant Function

(for H_2, Λ=.101, F^{66}_{9200}=161, R_c=.94)

Group	Mean
12th Grade Males	1.01
9th Grade Males	.89
9th Grade Females	-.91
12th Grade Females	-.99

(S.D. for discriminant = 1.00)

POSTSCRIPT

In proposing rubrics for a trait and factor theory of adolescent personality, this research report has raised far more questions than it has answered. Several hypotheses have been set forth without supporting evidence. These include the assertion that abilities are more closely linked to genetics than are motives, and thus have a primacy over motives. Put otherwise, it is the notion that abilities influence motives more than *vice versa*, and that environment controls motives more than it does abilities. There is the notion that certain aptitudes present in early life shape later achievements, and particularly that high Visual Reasoning is a prerequisite to substantial accomplishment in higher mathematics and technical pursuits. Hovering everywhere in the text are questions regarding the predictive validities for important life adjustment criteria of the abilities and motives factors.

Fortunately the appropriate data collections that can throw light on these questions exist at Project TALENT. Marion Shaycott's retest studies and Lyle Schoenfeldt's twin studies provide bases for inferences about genetic versus environmental determination. The one-year and five-year follow-ups provide the important life adjustment criteria required. William W. Cooley and the present author are collaborating in the preparation of a sequel to this report that will deliver the validation and prediction studies promised or hinted at in the preceding pages. This sequel will be organized in four sections:

I. Evidence on Genetic and Environmental Determination of Factors
II. Prediction of Attainments in Higher Education
III. Prediction of Vocational Placements Five Years Out of High School
IV. Prediction of Career Patterns

The anticipated report, which should be available in about a year, will document the relevance of the factor rubrics and measures to major issues in educational psychology and educational and vocational guidance.

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